INTERAVIA

REVIEW OF WORLD AVIATION

IN THIS ISSUE

Sun, Moon and Stars...

Price of this issue

U.S.A.:	80 cents
British Isles:	3 s
Switzerland:	Fr. 2.80
Netherlands:	Fl. 2.50
Denmark:	Cr. 5.-
Germany:	DM 2.75
France:	Fr. 250
Italy:	Lire 410
Japan:	U.S.$ 0.80
Sweden:	Cr. 3.50

VOLUME XI 12 DECEMBER 1956

NAVY FLIGHT SETS NEW RECORD

Allison Turbo-Prop-powered "Tradewind" opens new era in vital Pacific Fleet service

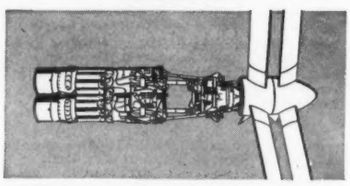
A few weeks ago the U.S. Navy opened a new chapter in aviation history when its giant aerial tanker – the Convair R3Y-1 Tradewind – set a new trans-pacific speed record for water-based aircraft. On its maiden round-trip flight from Alameda, California, to Keehi Lagoon, Honolulu, Air Transport Squadron TWO [VR-2] firmly established the Navy's long-standing belief in turbo-prop power as the jet age's most flexible and efficient power source. On its return flight the Tradewind covered the nearly 2,500 miles over water span in 6¾ hours, far surpassing the record on this route for this type aircraft.

Powered by four Allison twin power section turbo-prop engines driving contrarotating Aeroproducts Propellers, the Tradewind boasts nearly 24,000 horsepower–can lift its 80-ton weight from the water in 30 seconds, climb quickly to cruising altitude and cover more than 2,000 miles nonstop at speeds in excess of 350 miles per hour.

What makes this astounding aerial feat possible is the development of a whole new concept of powered flight–the culmination of 10 years of research by the Navy, Convair and Allison. It required the solving of one of the most complex engineering challenges in aviation history–perfecting a gas turbine engine of advanced design and mating it with a six-bladed contrarotating propeller.

The R3Y-1 Tradewind will refuel in flight eight jet fighters–*four at a time* –at speeds of more than 350 miles per hour. This new addition to the vast Pacific Fleet, the R3Y-1 will provide a vital service to our fast carrier task forces, further extending the range and striking power of the Navy's mighty air arm.

ALLISON DIVISION OF GENERAL MOTORS CORPORATION
Indianapolis, Indiana



R3Y-1 demonstrates versatility of Turbo-Prop power in jet-age transportation

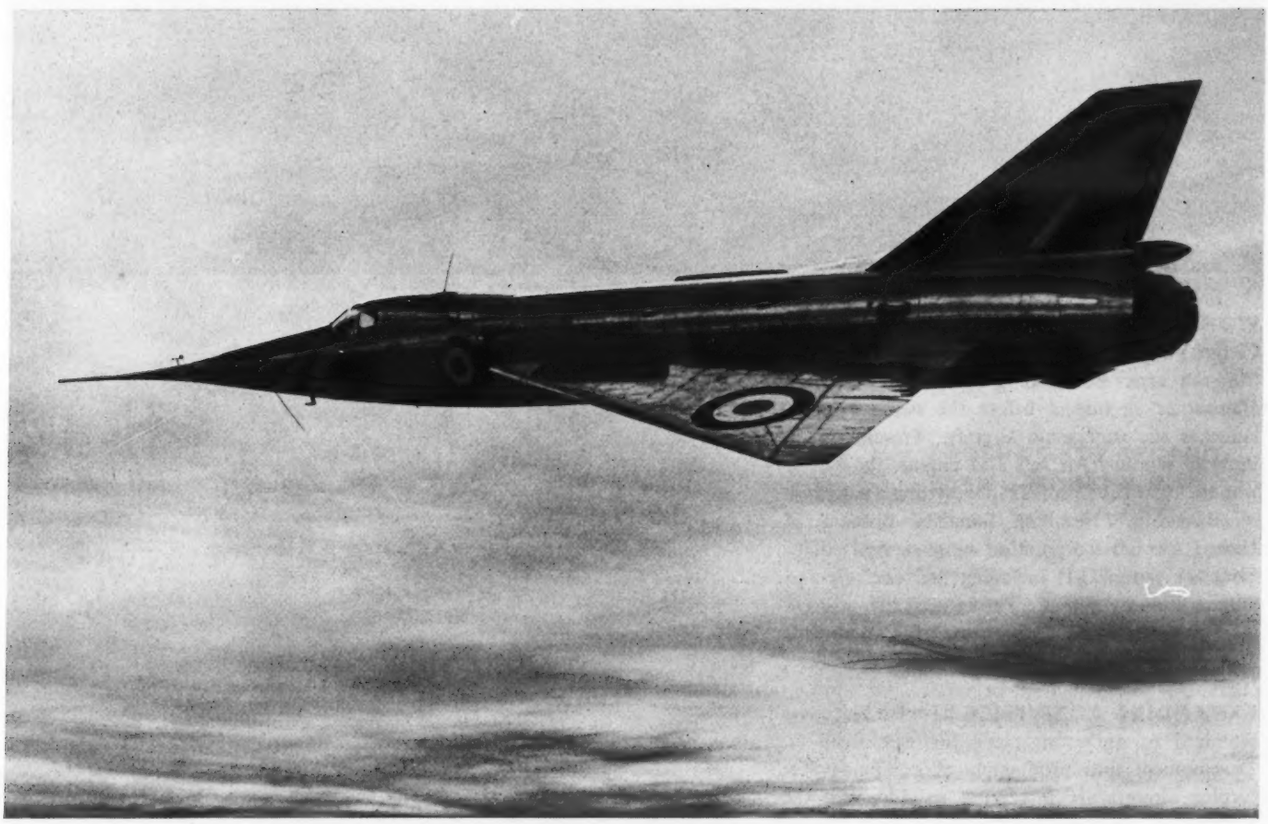
Record-breaking Navy R3Y-1 is powered by four T40 Allison Turbo-Prop engines like this–each having twin power sections driving contrarotating Aeroproducts Propellers. Both power sections in each engine give the R3Y-1 full power for rapid take-off and climb to cruising altitude. To gain best fuel economy for cruising, one power unit may be shut off entirely, allowing the other to operate at its most efficient setting. Either power section operates all six blades contrarotatively.

ALLISON
TURBO-PROP POWER
VERSATILE POWER FOR JET-AGE FLIGHT

FAIREY DELTA 2

Proved

World's Fastest Jet



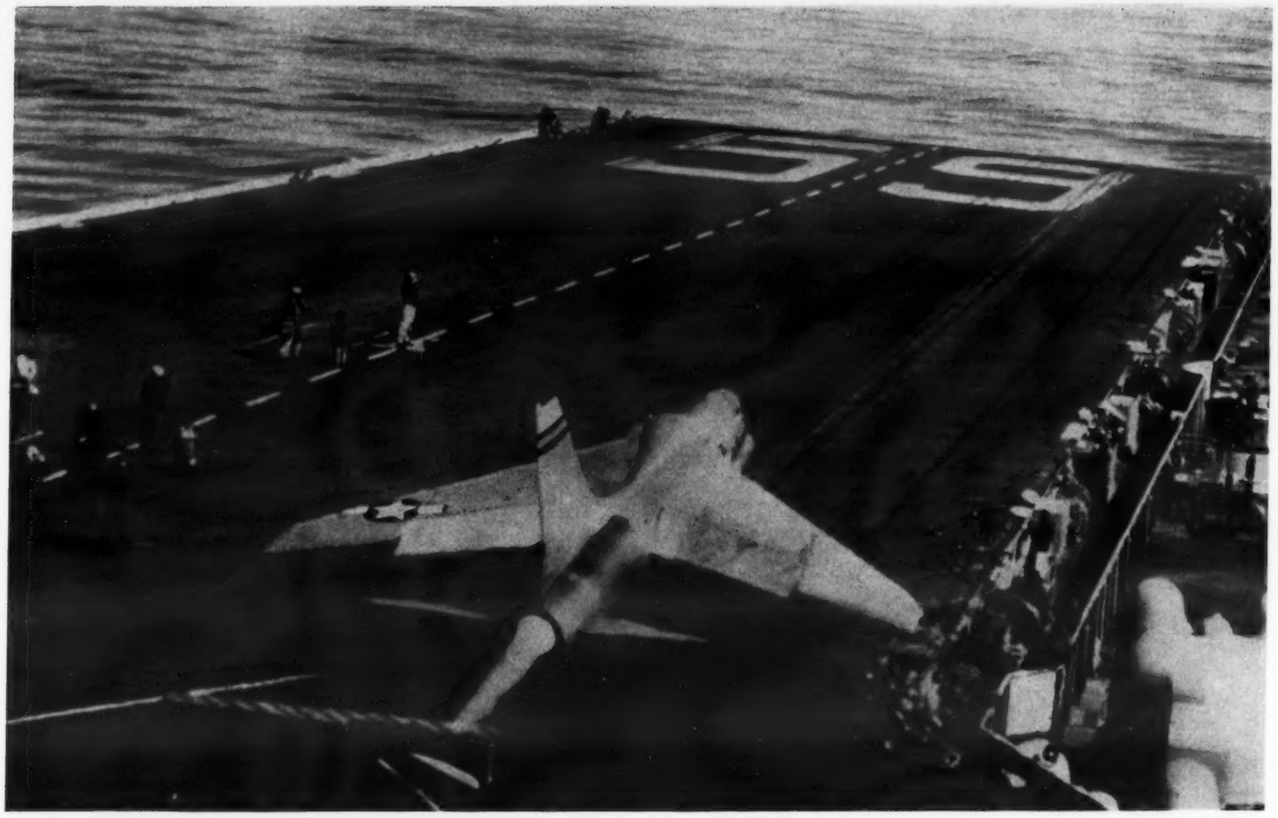
Powered by one Rolls-Royce AVON Jet Engine

FAIREY

THE FAIREY AVIATION COMPANY LIMITED - HAYES - MIDDLESEX - ENGLAND

ENGLAND - AUSTRALIA - CANADA

Around the World

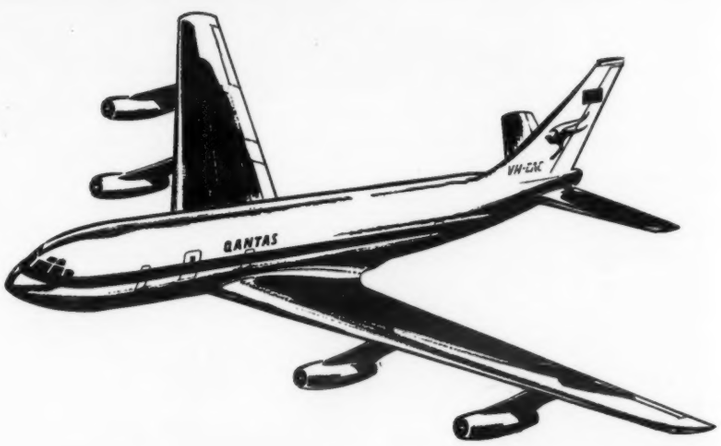


WORLD'S FASTEST NAVY FIGHTER, Chance Vought's F8U-1 *Crusader* is ready for takeoff from the carrier Forrestal. Flames shoot out of the afterburner an instant before the steam catapult launches the supersonic aircraft. Powered by a Pratt & Whitney Aircraft J-57 engine, the F8U-1 won the 1956 Thompson Trophy, setting a 1015 mph speed record. Hamilton Standard division of United Aircraft Corporation supplies vital equipment for the F8U-1, including fuel controls and air-conditioning systems. The fighter's two-position wing is in the " up " position used for all takeoffs and landings.

EXPANDING ACTIVITIES have led Hamilton Standard to announce plans for new facilities. Development and production of equipment for turbine aircraft are increasing steadily, and the backlog of commercial orders for propellers is at an all-time high.

A new 290-acre site near St. Petersburg, Florida, has been purchased for the division's Florida engineering operation. For some months preliminary activities in Florida have been carried on in rented facilities.

Hamilton Standard has also announced the creation of a new Electronic Department which will develop and produce new lines of electronic equipment for jet aircraft.



QANTAS EMPIRE AIRWAYS of Australia has ordered seven Boeing 707 Jet Stratoliners equipped with Pratt & Whitney Aircraft JT3 engines, commercial versions of the well-known J-57. The new jet airliners will enter service in 1959 on Qantas' route to London and on the Pacific route to the United States.

This purchase brings to 134 the number of Boeing 707s covered by contracts or letters of intent to purchase. Seventeen leading world airlines have now ordered fleets of Boeing 707 and Douglas DC-8 airliners equipped with Pratt & Whitney engines. Standard power plants for these Boeing and Douglas transports are JT3s and JT4s, commercial versions of the J-57 and the even more powerful J-75 engine.

with United Aircraft

CANADA'S OKANAGAN HELICOPTERS LTD. has accepted delivery of its first Sikorsky S-58, which joins the firm's fleet of five Sikorsky S-55s and other smaller helicopters. The S-58 went to work hauling cargo for construction projects in the Northern wilderness. The S-58 cruises at better than 100 mph, and can carry a two-ton payload on a 100-mile trip.

SABENA SETS RECORD WITH SIKORSKY S-58s

Sabena Belgian World Airlines, which recently received the first two of its fleet of 12-passenger Sikorsky S-58s, set a new city-center to city-center record with the two aircraft on October 4. They flew from Issy, Paris, to the heliport at Brussels in the record time of 1 hour, 16 minutes, an average of 146 miles per hour for the 185-mile distance. Sikorsky S-58s also are flying for New York Airways.

UNITED AIRCRAFT EXPORT CORPORATION *East Hartford 8, Conn., U. S. A.*

European Offices: 3/5 Warwick House Street, London SW1, England

PRATT & WHITNEY AIRCRAFT *Aircraft Engines*
HAMILTON STANDARD *Propellers and Jet Aircraft Equipment*
SIKORSKY AIRCRAFT *Helicopters*

VIATION
Aviennement S.N.C.A.S.O.
105, Avenue Raymond-Poincaré, Paris 16e

The nation's first jet transport-tanker is in the air

First production model of the Boeing KC-135 jet transport-tanker is shown above on a test flight. The Air Force has announced that production will be stepped up to a rate of 20 per month earlier than originally planned.

The KC-135 is a sleek, swept-wing craft capable of speeds in the 500-mile-an-hour range. It will refuel jet bombers and fighters while flying eight miles or more above the earth—at speeds best suited to jet flight. It is a versatile aircraft, convertible in a matter of hours from tanker into a military transport. As a transport it offers the full potential of jet-age operation for carrying personnel and critical cargo.

Design of the KC-135 is based on that of a prototype model which already has behind it more than two years of intensive flight testing. The KC-135 incorporates many design advances that could come only from such a flight test program. This experience background enabled Boeing to cut production time on the first KC-135 by 20 per cent under normal estimates for a first production model.

The new Boeing transport-tanker also benefits from the knowledge Boeing has gained developing and producing more than 1400 B-47 and B-52 multi-jet bombers, the backbone of the Strategic Air Command's nuclear weapons carrier forces. In the not too distant future, this team of revolutionary Boeing bombers will be joined by the newest Boeing jet, the KC-135 transport-tanker.

BOEING

ORLY LE BOURGET LOGNES MEAUX MITRY PER
LOGNES MEAUX MITRY PERSAN-BEAUMONT P
ORLY LE BOURGET LOGNES MEAUX MITRY PE

AEROPORT DE PARIS

ORLY LE BOURGET TOUSSUS-LE-NOBLE CHAVENAY CHELLES COUILOMMIERS CREIL GUYANCOURT ISSY-LES-MOULINEAUX ORLY LE BOURGET LOGNES MEAUX MITRY PERSAN-BEAUMONT PONTOISE SAINT-CYR-L'ÉCOLE ORLY LE BOURGET TOUSSUS-LE-NOBLE
TOUSSUS-LE-NOBLE CHAVENAY CHELLES COUILOMMIERS CREIL GUYANCOURT ISSY-LES-MOULINEAUX ORLY LE BOURGET LOGNES MEAUX MITRY PERSAN-BEAUMONT PONTOISE SAINT-CYR-L'ÉCOLE ORLY LE BOURGET TOUSSUS-LE-NOBLE CHAVENAY CHELL
ORLY LE BOURGET TOUSSUS-LE-NOBLE CHAVENAY CHELLES COUILOMMIERS CREIL GUYANCOURT ISSY-LES-MOULINEAUX ORLY LE BOURGET LOGNES MEAUX MITRY PERSAN-BEAUMONT PONTOISE SAINT-CYR-L'ÉCOLE ORLY LE BOURGET TOUSSUS-LE-NOBLE

PASSENGER MOVEMENTS : 1949 760,000 - 1952 1,325,000 - 1954 1,750,000 - 1955 1,925,000

CROSSROADS OF THE WORLD

to

AMERICA
AFRICA
ASIA

On the whole of AIR FRANCE's *long-distance network you can be sure with*

the **Super Constellation**

of making the fastest and most comfortable trips

AIR FRANCE
operates 72 **"Super Constellation"** services every week to major cities throughout the world

Close networks inside each continent where agreements with associated airlines enable you to reach all important centres

AIR FRANCE
offers sleeper chairs and reclining seats on all its long-distance services, beds on international services and private cabins on the **"Parisien Spécial"**

AIR FRANCE - AIR CREDIT
enables you to pay for your journey in 3, 6, 9, or 12 monthly instalments. You fly today and pay tomorrow.

AIR FRANCE
always in the forefront, is preparing a future worthy of its present. In ordering 12 Caravelles and 10 Boeing 707s it is one of the first airlines to advance into the jet age

Travel agencies and AIR FRANCE are at your service to advise you and prepare for you the best possible journey

the **Super G**

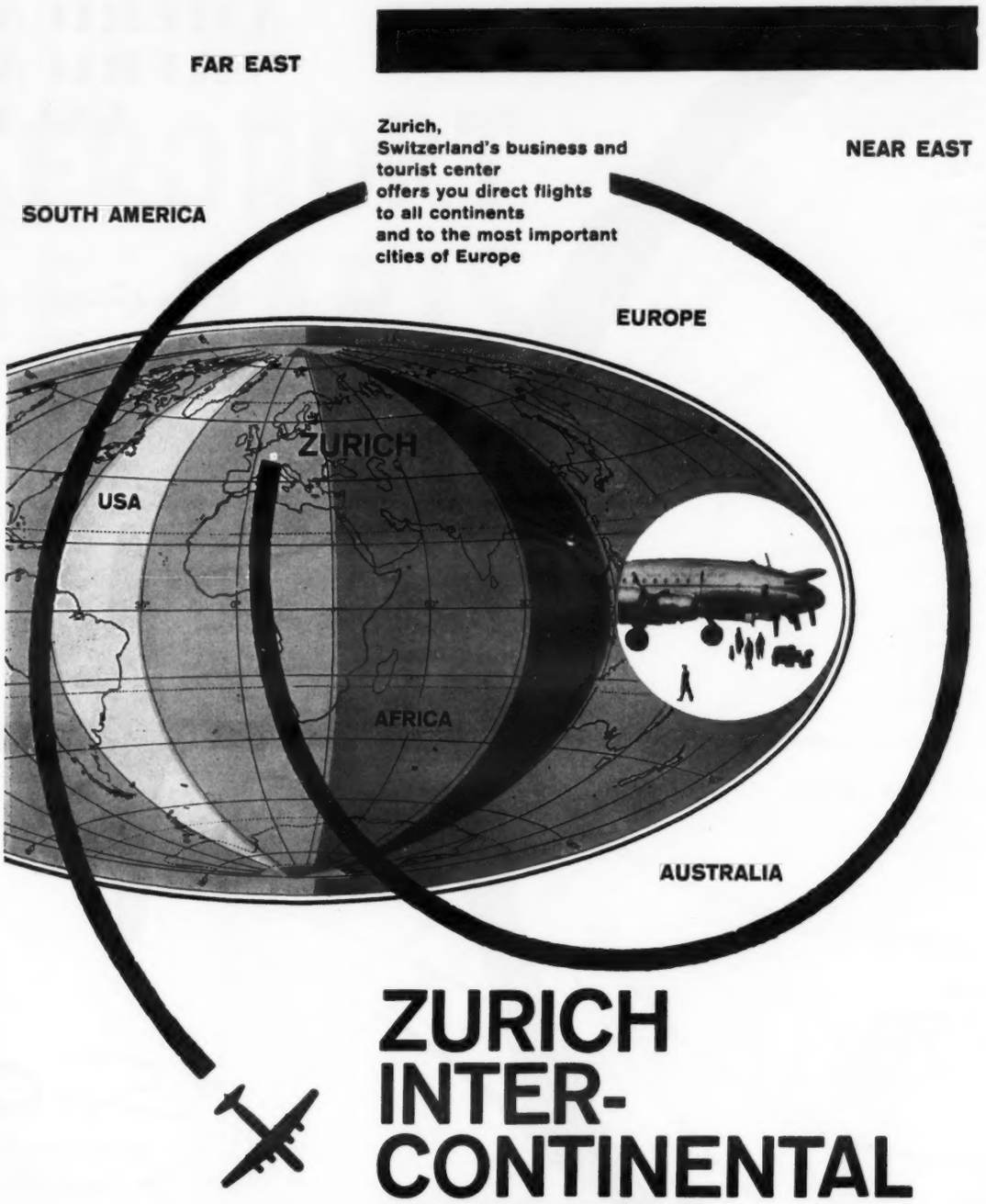
the fastest aircraft over the longest distances is now in service on AIR FRANCE's long-range network

AIR FRANCE

the long-distance expert

37 years of experience and progress over the world's longest network

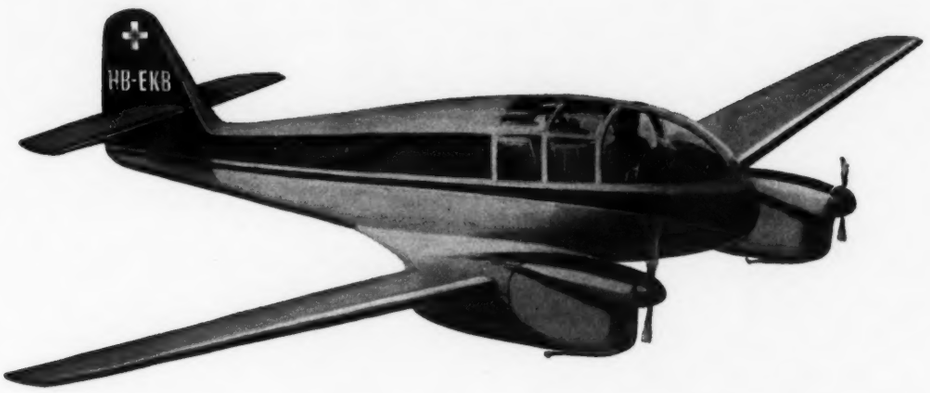
931



ZURICH INTER-CONTINENTAL AIRPORT

Important connecting point in World-Wide Air-Traffic

SuperAero



OMNIPOL AG.

Washingtonova 11 Praha 3 Czechoslovakia

Only wings can help you

The SUPER AERO is an ideal modern means of transport, fast, reliable, always ready for use. It is an all-metal twin-engined four-seater, valuable for business trips, private touring, sports, training, and often used as taxi aircraft. It will cut down your travelling time, give you perfect comfort and offer you all the pleasures of flying. Prospectus and demonstration on request.

Represented by : **AERO-CRAFT ZÜRICH**

Bahnhofstrasse 77 (Switzerland) Telephone (051) 25 55 02

Personally speaking

—a series of contributions on questions of the hour by leading international aviation personalities.

A. VERNIEUWE

—Senior Vice-President Sabena, and one of the greatest authorities on the operation of Civil Helicopter Services.

Civil Helicopter Operation

The choice of Brussels, in 1953, as the centre of the first helicopter service was no accident. If one looks at a map of Western Europe, Brussels is seen to lie at the centre of a very industrialised and densely populated area (about 200 inhabitants per sq. km.). In addition, by drawing a circle round the Belgian capital, representing the average range of modern helicopters (about 350 km.), one includes the important cities of London, Paris, Amsterdam and all the large towns of the Ruhr. In this way the most favourable conditions for the sensible development of the helicopter are achieved: density of population, large numbers of industrial and urban centres with comparatively short distances between them, a favourable geographical relief.

In the development of commercial aviation, where the urgent need is to reduce travel time between cities and airports, the helicopter has an important part to play. Owing to the increased volume of traffic on roads, and the fact that modern airfields are being built further away from towns, the air traveller is losing an appreciable amount of those precious minutes which flying has so largely saved. To this problem, the helicopter provides an obvious and practical solution.

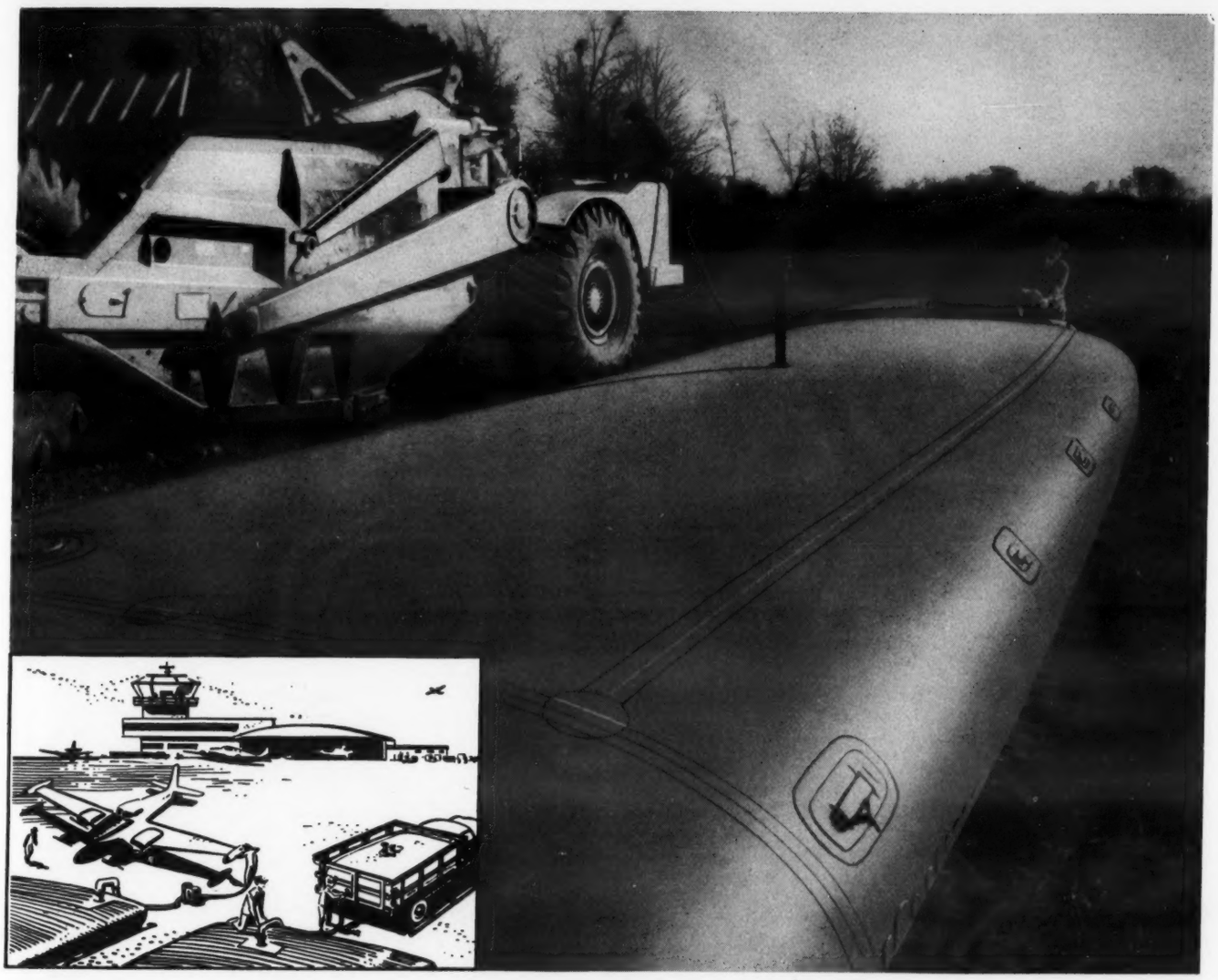
Finally, towns with a helicopter service attract new traffic. For, not only does the helicopter enlarge the hinterland of the town it serves, it also considerably increases the accessibility of the airport from which it operates.

Whatever future solution commercial aviation adopts for transport over short distances, the helicopter will have fulfilled present needs and rendered service to the community by enabling large towns without aerodromes also to have access to air transport.

AVIATION BP SERVICE

serves aviation well

THE BRITISH PETROLEUM COMPANY LIMITED



New Collapsible "Pillow Tank"

for portable storage of fuels for airplanes and construction equipment

What you see here is a collapsible 10,000-gallon fuel tank which weighs only 850 pounds when empty—and it can be rolled up like a rug for easy transportation.

Made by Goodyear, these tanks come in capacities of 900 and 3,000 gallons as well—can be set up by untrained personnel and be pumping in a matter of minutes.

Ideal wherever economical transportation or temporary storage of bulk liquid is desired, these Pillow Tanks are as durable as they are practical.

Constructed of plies of nylon fabric and a special gasoline-resistant synthetic rubber, these rugged containers have been proved in lengthy service in climates ranging from —40° F. to 160° F.

For complete information on these revolutionary collapsible, portable Pillow Tanks by Goodyear, you are invited to write for our brochure which gives all details and technical data. The Goodyear Tire & Rubber Export Company, Aviation Products Dept., Akron 16, Ohio, U.S.A., or The Goodyear Tyre & Rubber Company (Great Britain) Ltd., Wolverhampton, England.

GOODYEAR
AVIATION
PRODUCTS

OFEMA

OFFICE FRANÇAIS D'EXPORTATION DE MATÉRIEL AÉRONAUTIQUE

4, rue Galilée PARIS XVI^e Telephone : KLEber 89-10

Sales office

for the exportation of the French aircraft industry's products

DEPENDABLE ROCKET POWER

• SOLID- AND LIQUID-PROPELLANT ROCKETS FOR ASSISTED TAKEOFF AND IN-FLIGHT THRUST AUGMENTATION OF PILOTED AIRCRAFT • SOLID- AND LIQUID-PROPELLANT BOOSTERS AND PRIME POWER PLANTS FOR MISSILES • THRUST REVERSERS • UPPER-ATMOSPHERE RESEARCH ROCKETS • UNDERWATER PROPULSION DEVICES • ELECTRONICS AND GUIDANCE • ORDNANCE AND ARMAMENT • ARCHITECT-ENGINEER SERVICES

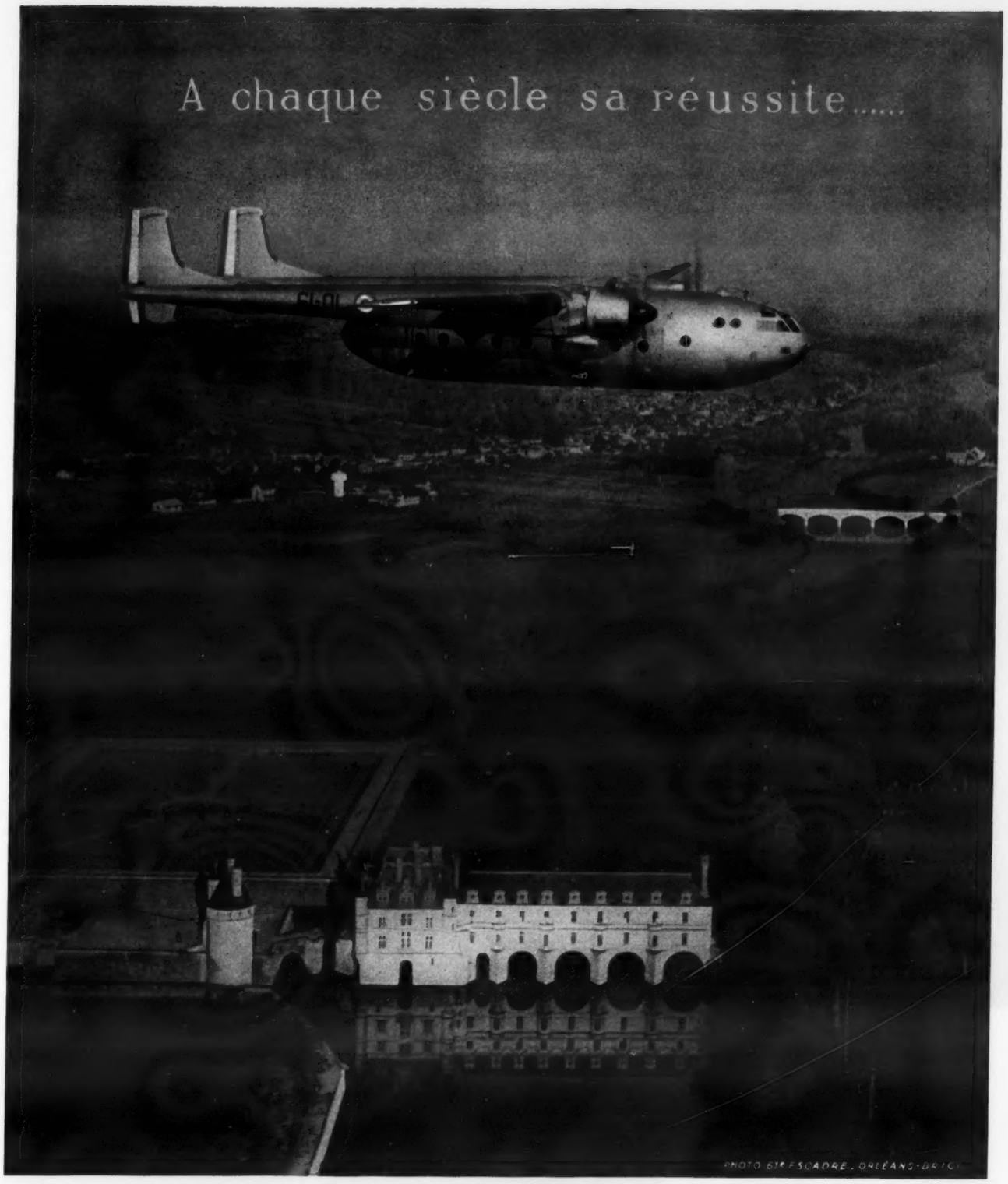
Aerojet-General CORPORATION

A Subsidiary of The General Tire & Rubber Company

THE GENERAL TIRE

AZUSA, CALIFORNIA

SACRAMENTO, CALIFORNIA

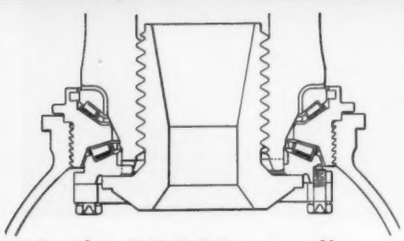


S.N.C.A.N

Société Nationale de Constructions Aéronautiques du Nord

2 à 18, RUE BÉRANGER - CHATILLON-S/S-BAGNEUX
(SEINE) TÉL. ALÉSIA 57-40

937



In the ROTOL propellers of the VICKERS VISCOUNT

Timken tapered-roller bearings are used in the blade mountings of Rotol variable pitch propellers, used on the Vickers Viscount and other famous aircraft.

BRITISH TIMKEN LIMITED, Duston, Northampton (Head Office) ; Daventry and Birmingham, England

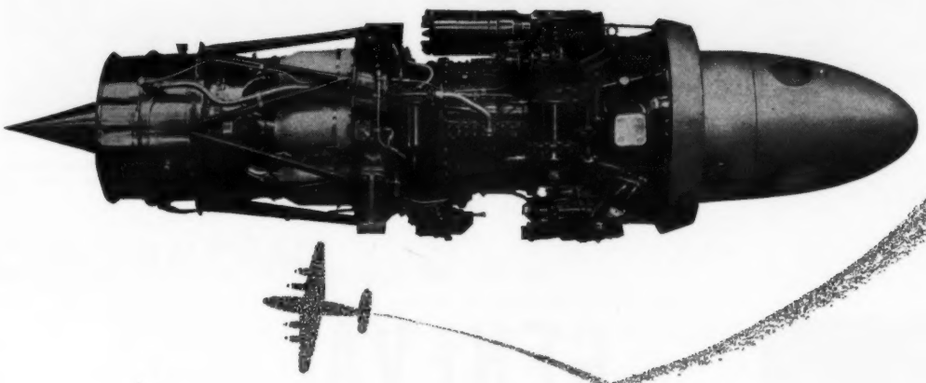
TIMKEN

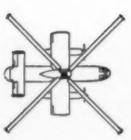
Regd. Trade Mark : Timken

tapered-roller bearings

MADE IN ENGLAND

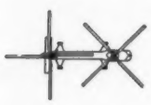
3 engines of increasing importance





ELAND The Convair 340 aircraft converted to Eland engines will be on demonstration flights in Europe during this year. Another aircraft conversion to *Elands* is the Elizabethan, which will be evaluated on BEA routes. Napier *Elands* fitted with auxiliary compressors for the tip-driven rotor system will power Fairey's new large transport helicopter, the Rotodyne.

ORYX The Napier *Oryx* 780-950 gas h.p. turbo-gas-generator provides the hot gas which is ducted to the rotor head for the propulsion of helicopters by jet reaction at the rotor blade tips. This system eliminates all mechanical transmission. The *Oryx* has been officially Type Tested at 780 and 865 gas h.p.



GAZELLE *Gazelle* 1260-2000 s.h.p. A rugged new free turbine engine for helicopters —selected for the Royal Navy Westland S-58 " Wessex " and the R.A.F. twin-rotor Bristol 192. For ease of installation it can be mounted in any position between the vertical and horizontal. Helicopters demand though, reliable engines—the *Gazelle* is designed for strenuous duty, long service between overhauls while its outstanding simplicity means economical and speedy maintenance.

Designers and manufacturers of Rocket Engines and Ramjets

NAPIER MORE POWER AT LOWER COST

Partners in Progress with The ENGLISH ELECTRIC Company Ltd.

D. NAPIER AND SON LIMITED - LONDON W. 3 - ENGLAND

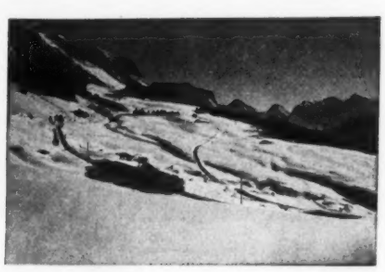
For your winter sports holiday

Geneva international airport occupies a key position in relation to the winter sports centres in Valais and Savoy. By flying to Geneva you save time and prolong your winter holiday. Special direct services to the French centres.

Ready for the Races in the Alpes vaudoises.

Oh boy ! What a view on the Mont-Blanc (highest peak in Europe) and the French Alps. Shot from the Swiss Jura.

Can you imagine how happy these two people feel ? The " Suger cake " is the Matterhorn (Alpes valaisannes).

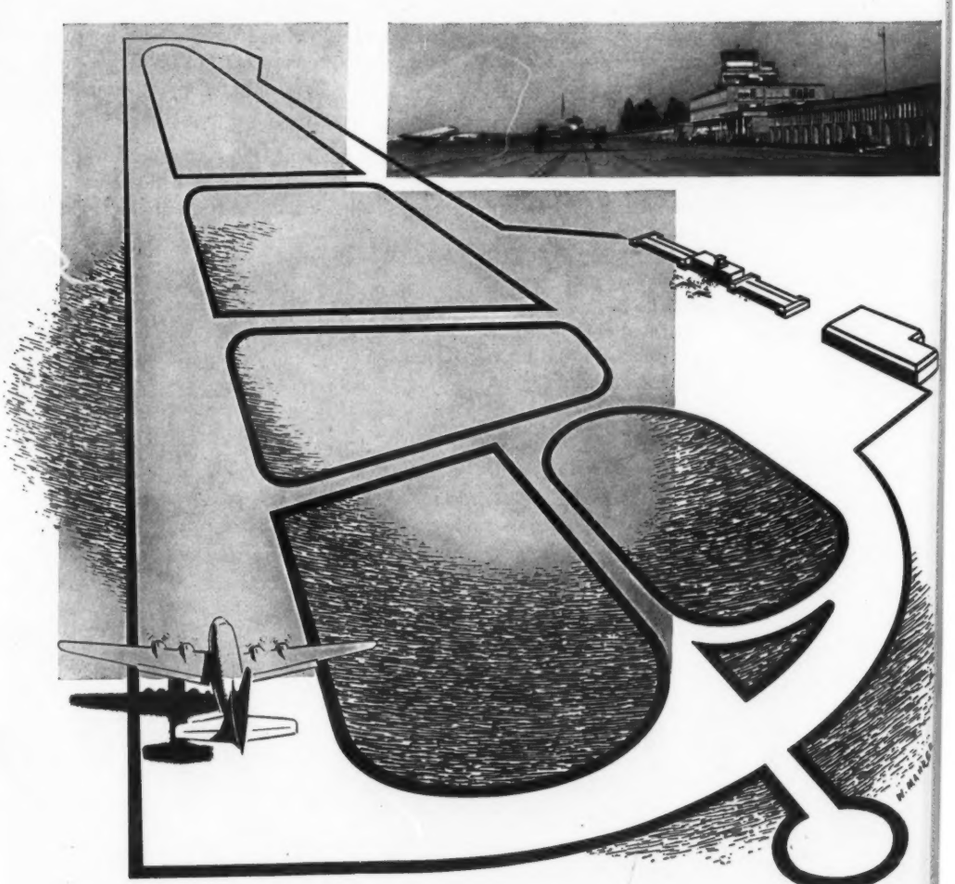


On the sunny side of good old Earth. This train will take you right into the heart of the Jungfrau (Bernese Oberland).

And here is the way to climb a mountain without getting tired. In front of the majestic Mont-Blanc, French Savoy.

GENEVA

INTERNATIONAL AVIATION CENTRE



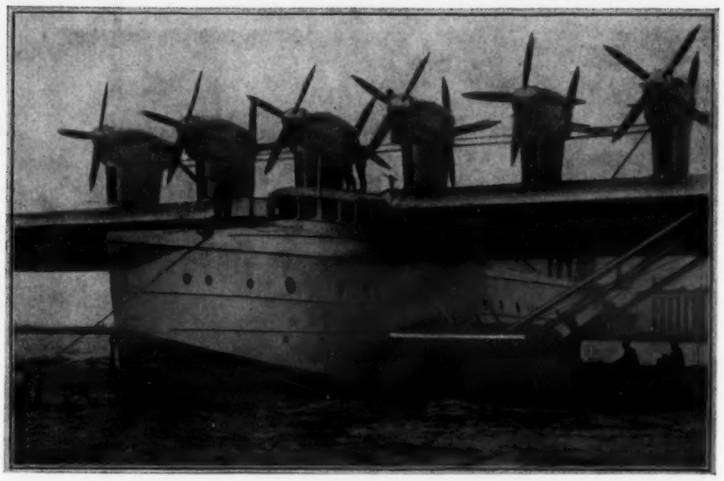
1930...

For ocean crossings? — The seaplane ! . . .

To carry fifty passengers over 600 miles?

twelve 600/650 h.p. engines ! . . .

Safety ? ? . . .



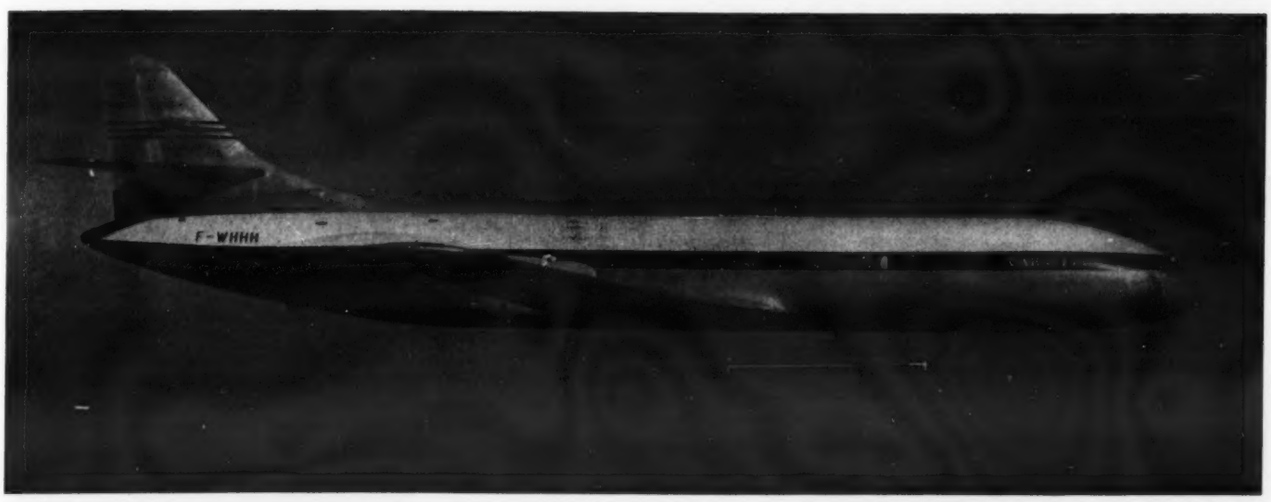
TODAY

four-engined aircraft cross the Pacific . . .

AND TOMORROW

aircraft with **two** jets . . .
high quality = Rolls-Royce Avon
power = more than 10,000 lbs. thrust

THE "CARAVELLE"



will offer 70 passengers

a speed of 480 m.p.h. over 1,800 miles
with maximum safety
with unequalled comfort

will ensure operators

exceptional economy
thanks to simplified maintenance
thanks to accelerated turn-round

SUD-EST AVIATION

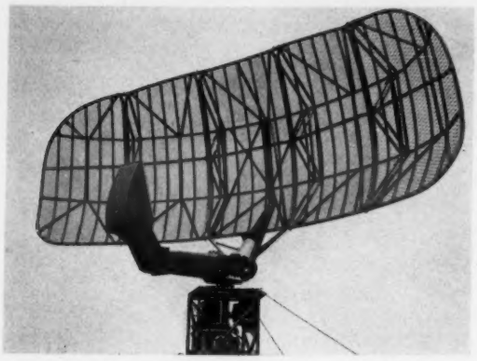
SOCIÉTÉ NATIONALE DE CONSTRUCTIONS AÉRONAUTIQUES

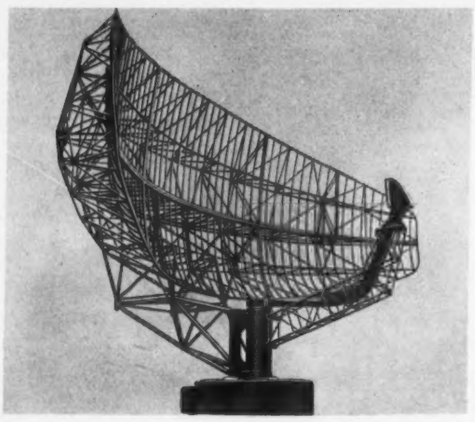
37, Bd de Montmorency — PARIS — 16e

Tel. BAGatelle 84.00

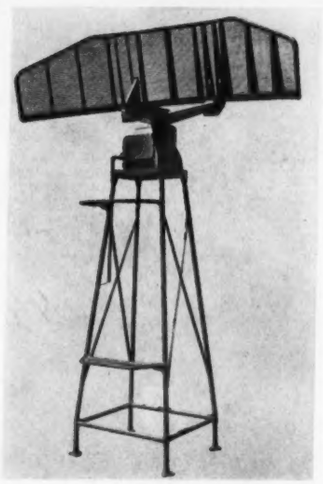
Long range antenna

Antenna for tactical radar



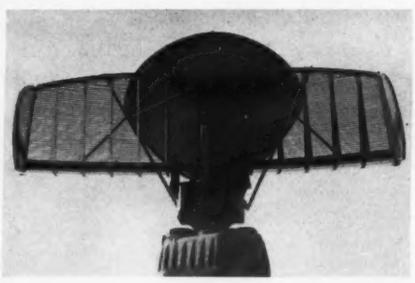


Long range antenna

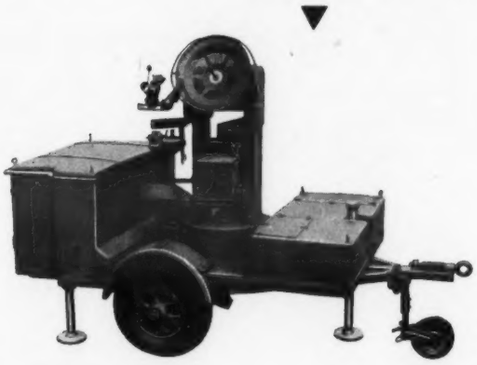


Antenna for ships radar

Antenna for naval detection radar



Radar for anti-aircraft fire



microlambda

ADVANCED ELECTRONICS

Radar for civil and military use - Underwater electro-acoustics - Microwave telecommunications - Railway electronics - Industrial electronics

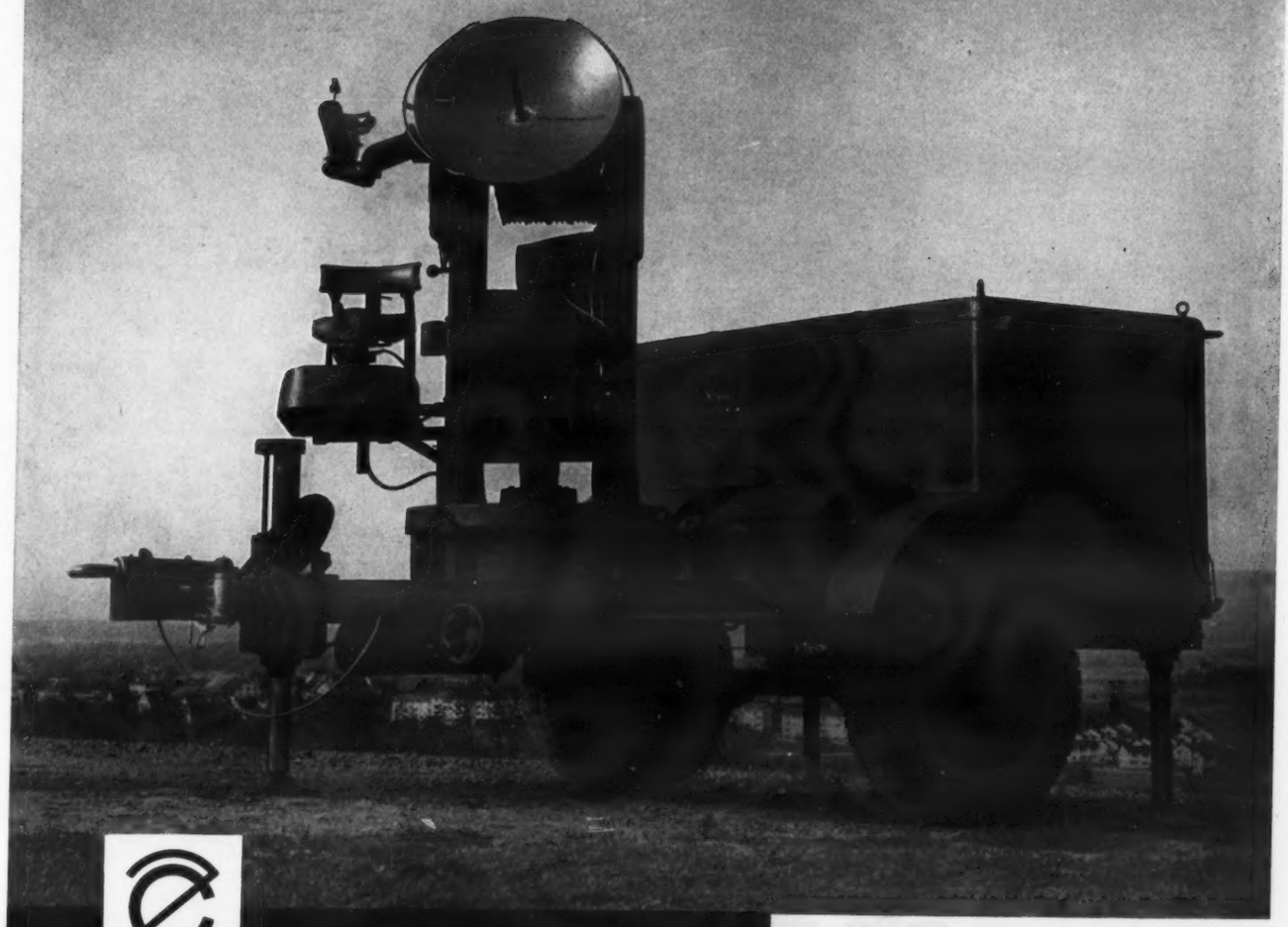
MICROLAMBDA — Via Ferdinando di Savoia, 6 — ROME — Plant at Fusaro — NAPLES

New GUN FIRE CONTROL SYSTEM

THE BAT

For 40 mm A. A. Batteries

consisting of: MLT-5B Fire Control Radar Set (MICROLAMBDA, ROMA) for target acquisition and for automatic tracking, optical tracker and electronic computer with a total weight of less than 3 tons. / Simplified operation. / High mobility and quick emplacement. / Quick computation of gun data with maximum accuracy. / Training of maintenance personnel has been simplified considerably through the application, wherever possible, of techniques and components similar to those employed in the design of the Contraves F/90 Director.



CONTRAVES ITALIANA S. p. A. ROMA

Norway Orders Saab Safir

for Air Force Training

The Royal Norwegian Air Force ("Flyvåpnet") recently signed a contract with the Saab Aircraft Company for the supply of a substantial number of Saab 91 B-2 Safir trainers. These are now being delivered.

All initial flying training within the Norwegian Air Force will in the future take place on this Swedish aircraft.

Thanks to its excellent flight characteristics, the Saab Safir can be used as the only piston-engined trainer up to the advanced jet training stage, as is now the case in the Royal Swedish Air Force. However, the Safir is not only in large-scale use as a military trainer, it has also attained a rather unique position as a trainer for airline pilots.

The SAAB SAFIR

The SAAB SAFIR
is now being used
as a trainer by the following organizations:
The Royal Swedish Air Force
The Imperial Ethiopian Air Force
Rijksluchtvaartschool of Holland
Deutsche Lufthansa
Sabena Belgian World Airlines
Air France
The Indonesian Government's Civil Flying Training School

SVENSKA AEROPLAN AKTIEBOLAGET (Saab Aircraft Company) · LINKÖPING · SWEDEN

SNECMA

150, Boulevard HAUSSMANN - PARIS-8e

945

HAVING A FLUTTER

This is an electronic analogue computer, designed and built by ENGLISH ELECTRIC for work at their Aircraft Division's Research establishment at Warton on problems of aircraft flutter and stability. A mathematician with a desk calculator would find it fairly easy to solve problems of flutter in two degrees of freedom, very difficult to solve problems in three degrees of freedom, and impossible to go further. This machine solves, in a few minutes, problems of flutter in six degrees of freedom. This does not mean that the mathematician becomes redundant. To produce the figures for a family of problems for the computer to work on may easily take him a fortnight. The computer then does in an hour or so what would take the mathematician 6 months to do—supposing he could do it at all.

On problems of stability the computer can do a theoretical analysis, which it can then translate into practical terms with the aid of a mock-up cockpit, complete with flying controls, simulated instruments and a cathode-ray artificial horizon. In this way a pilot can study the effects of different control and stability characteristics without ever leaving the ground—and can get a fair approximation of the feel of a projected aeroplane before it has been built.

Thus, with ever more elaborate equipment, are ENGLISH ELECTRIC designing today the aeroplanes of tomorrow. For when aircraft are required to fly at stratospheric heights and supersonic speeds, hopes and hunches must give way to science and certainty.

Design starts from an attitude of mind

'ENGLISH ELECTRIC' aircraft

Partners in Progress with Marconi and Napier in THE ENGLISH ELECTRIC GROUP

QUEENS HOUSE · KINGSWAY · LONDON · WC2

INTERAVIA

Deadline Notes

No. 12, 1956

THE AIR TALKS between Italian and Swedish officials, which began on October 15th in Rome, have ended without agreement in principle. The two governments will resume negotiations before next September when the provisional authorization under which S.A.S. has been using Italian airports expires.

THE WEST GERMAN PARLIAMENT has ratified the air agreements with Britain, France, Belgium, Eire and Switzerland. The agreements will now be submitted to President Heuss for signature.

THE DEVELOPMENT OF FRENCH AIR TRAFFIC in 1955 showed two important trends, according to figures published by the Secretariat General for Civil and Commercial Aviation: the total volume of traffic increased by 14% over 1954, and Air France's share in it dropped from 74% to 70.5%. This was due largely to the rise in the volume of traffic carried by Metropolitan France's two major independent operators, U.A.T. and T.A.I. (+ 26%) and by the three North African carriers (+ 38%). - Compared with the 20% increase for world air traffic as a whole (the figure given by I.C.A.O.), France lagged behind; it should not be forgotten, however, that the 17% increase from 1953 to 1954 put France ahead of the world average of 10%.

UNION AEROMARITIME DE TRANSPORT, a French independent operator, has announced the purchase of five Douglas DC-8 jet transports, subject to French Government approval. The two-part order consists of three aircraft to be delivered in spring 1960 and an option on two more in early 1962. No decision has yet been taken on whether these aircraft will be powered by Pratt & Whitney JT4s or Rolls-Royce Conways. Cabin layout will be a combination first-class/tourist version for 26 first-class and 64 tourist class passengers. Total cost of the U.A.T. order is approximately $35,000,000.

INCREASED BORROWING POWER FOR B.O.A.C. AND B.E.A.: A bill which will increase the borrowing powers of British Overseas Airways Corporation from £80,000,000 to £160,000,000 and of British European Airways from £35,000,000 to £60,000,000 has had its second reading in the House of Commons. In the case of B.O.A.C., the Treasury will back a loan from the International Bank for Reconstruction and Development or the Export-Import Bank of Washington, should this be necessary to finance the purchase of aircraft manufactured in the United States.

SEABOARD AND WESTERN AIRLINES introduced new air freight schedules on December 1st with Lockheed Super Constellations. The new service will provide a transatlantic freight capacity of 400,000 lbs. weekly, or double Seaboard's previous capacity. Use of Super Constellations reduces flying time from New York to London to 12 hours and from New York to Frankfurt to 15 hours. The new schedule also provides greater frequency of service to major European cities. As a result, services to London and Frankfurt are increased to six flights weekly; Stuttgart five flights weekly; Glasgow, Amsterdam, Brussels, Nuremburg and Hamburg, three flights weekly. The frequency of westbound services will also be increased; from London to six flights weekly; Frankfurt and Munich five flights weekly; Zurich, Paris, Dusseldorf and Brussels three flights weekly. - It will be recalled that Seaboard and Western initiated scheduled freight service in the United States and Western Europe last April. Last year it ordered five Lockheed L-1049Hs (cargo version of the Super Constellation), the first of which is due to be delivered during December.

LOS ANGELES INTERNATIONAL AND SAN FERNANDO AIRPORTS earned a joint net profit of $1,451,171 in the 1955-56 fiscal year, an increase of $365,965 over the previous year. Total revenue amounted to $2,805,110, direct operating expenses reached a total of $841,077 and depreciation amounted to $512,862. Both airports are owned and operated by the Los Angeles municipality.

A DOUGLAS DC-7C has set a new distance record for commercial airliners by flying 5,959 miles non-stop from Long Beach, California, to Stockholm. The aircraft took 21 hours 41 minutes and 18 seconds. Average cruising speed was 279 m.p.h. and the flight was made at an altitude of between 12,960 and 16,990 ft. The previous record was established in 1953 by a DC-6B which flew non-stop from Los Angeles to Paris, a distance of 5,770 miles.

DE HAVILLAND AIRCRAFT (CANADA) LIMITED has to date received orders for some 150 Otter single-engined aircraft, including more than 100 for the Royal Canadian Air Force, United States Army and Navy.

FAIREY AVIATION CO. LIMITED has confirmed receipt of a contract for development of two prototypes of the Rotodyne compound helicopter. The first is to be ready for flight testing next spring.

* From INTERAVIA's world-wide news service, including INTERAVIA AIR LETTER, the daily international aviation news digest. = No part may be reproduced without written permission.

SUD-EST AVIATION has opened a sales office at 500 Fifth Avenue, New York 36, N.Y. Engineer General C. Teyssier, former Director of Air Navigation at the Secretariat General for Civil and Commercial Aviation, and Engineer Darrieus are in charge of the new office, which will be responsible for the company's sales activities in the United States, Canada and Mexico.

FIAT has received a sub-contract from Sud-Est Aviation, under an agreement concluded in June 1953 providing for collaboration in the field of helicopter production, for license manufacture of parts for Sikorsky S-58 helicopters ordered by the French Government.

LEAR S.A., Geneva, has begun production of Lear automatic pilots. So far, 80 per cent of the orders received have been passed on to sub-contractors. The company's order backlog at present totals $1,000,000. The Geneva plant employs more than 100 persons, a figure which will probably be doubled during the first half of 1957 and may eventually reach 2,000.

MARTIN INTERNATIONAL is a new wholly owned subsidiary of The Martin Company which will explore and develop world markets for nuclear powered electrical generating systems. George B. Shaw, at present Martin's Vice President-Procurement and former Director of Commercial Sales, has been named President of the new company.

THE LAST OF 888 BOEING C-97 STRATOFREIGHTERS was delivered to the U.S. Air Force at Renton, Washington, recently and was flown to Lincoln Air Force Base, Nebraska, where it joined the 98th Air Refueling Squadron of the Strategic Air Command. The delivery marked the end of a 12-year Stratofreighter programme at Boeing Airplane Co.'s Renton plant.

CEYLON HAS OFFERED THE WEST GERMAN AIRLINE LUFTHANSA the use of Ceylon airports in return for traffic rights on commercial airports in Germany. Transport Minister Maithripala Senanayake also has invited an Italian Government representative to visit Ceylon early next year to discuss reciprocal air traffic rights.

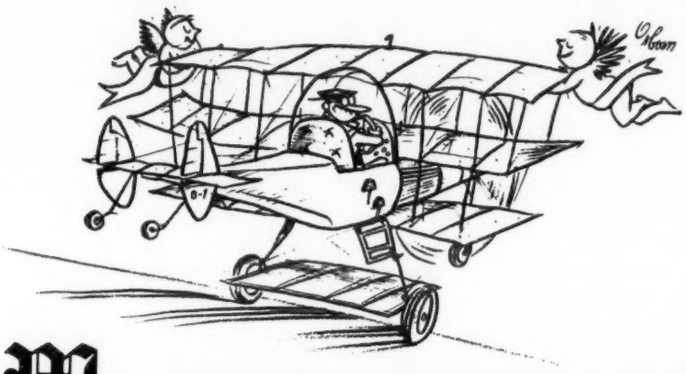
THE GENERAL MEETING OF LUFTHANSA STOCKHOLDERS on December 4th will be asked to authorize an issue of new shares which would raise the company's basic capital of 80,000,000 DM by a maximum of 40,000,000 DM. The shares would be offered to existing stockholders only.

*

WORKSHOP BRIEFS . . .

The U.S. Civil Aeronautics Administration is to test three new runway lighting systems during the coming months in a search for methods of overcoming deficiencies in the systems at present in use. By March 1957 C.A.A. plans to have worked out exact regulations for improvements in runway lighting to ensure that both civil and military requirements are met. It is also planned to submit these regulations to I.C.A.O. for possible acceptance as international standards. * Two prototypes of a new three-engined "flying platform" (with 44 h.p. two-stroke engines) have been ordered from Hiller Helicopters for the U.S. Army. * A new version of the Grumman Tiger, designated F11F-1F, is being tested. Unlike earlier versions which have a J-65 jet with afterburner, the F11F-1F is powered by a General Electric J-79 jet with afterburner. * The Bristol Centaurus 373 piston engine with direct fuel injection (take-off power 3,150 h.p.), which was developed for possible installation in the Blackburn and General Aircraft Beverley transport, is now to be tested in flight. * The Scottish Aviation Twin Pioneer short range feeder aircraft has been granted a type certificate. * A pre-production batch of Temco XKDT-1 target aircraft with rocket power has been ordered by the U.S. Navy. It is reportedly capable of top speeds in the neighbourhood of Mach 1 and altitudes of up to 50,000 ft. * An American Doman helicopter (probably a YH-31) has made a series of demonstration flights to representatives of the Brétigny Flight Test Centre, at the request of Générale Aéronautique Marcel Dassault. It is rumoured that Dassault plans to build this helicopter under license in France. * The helicopter division of Sud-Est Aviation has completed work on the SE.3150 version of the Alouette turbine-powered helicopter. The new version has a longer and wider cabin for seven persons; power plant 1 Turbomeca Artouste. * Sikorsky has converted an HR2S-1 Navy helicopter (Army designation H-37A) to take early warning radar equipment, under contract to the U.S. Navy. The latter plans to use this helicopter to determine whether the early warning range of ships' radar can be increased by using helicopters as radar carriers. * A U.S. Air Force Boeing B-52 Stratofortress eight-jet long-range bomber landed at Baltimore international airport on November 25th after being in the air - with several in-flight refuellings - for 31 1/2 hours and having covered a distance of roughly 16,000 miles. It had taken off from Castle AFB, California, on November 24th and flown over Thule (Greenland), the North Pole, Anchorage (Alaska) and San Francisco. * First Boeing-produced KC-135 tanker will be delivered to the Strategic Air Command's B-52 base at Castle AFB, Calif., in late spring 1957. The 93rd Bomb Wing is now organizing a training cadre for a check-out of training crews. Castle AFB will be the centre of the training personnel for all SAC units. * The Mirage III has made its first flight at Melun-Villaroche, piloted by Dassault Assistant Chief Test Pilot Glavany. This aircraft, fitted with a SNECMA ATAR G with reheat, is the first French "coke bottle" machine to fly.

* * *



May a squadron of Guardian Angels escort you through 1957

* * *

INTERAVIA
Editors and Publishers

Sun, Moon and Stars

The title has a seasonal sound. It probably sounded tempting to the Editors, for it was decided several months ago that this year's Christmas issue should be devoted to a topical, but peaceful subject, namely space travel. And as the outlook on our own planet was far from rosy in November 1956, it seemed doubly indicated to look around for happier stars.

There were also, however, more concrete reasons for choosing this subject. We are approaching the beginning of the *International Geophysical Year* *, which will see the first practical beginnings of space travel in the form of the launching of the first artificial earth satellites. In the autumn of 1956 we attended two congresses in Italy at which well-known scientists and technically qualified officers from throughout the world expounded their views on space vehicles and rockets. The impression was that research has taken a major step forward and moved closer to practice.

*

Nevertheless, we realize that some of our readers may well shake their heads over the contents of one article or another, just as we have done. We can imagine that airline heads, for example, will not altogether follow the thinking of certain highly esteemed scientists when they proclaim in all seriousness that man will one day travel the length of the Milky Way at the speed of light (300,000 kilometres per second)... We have as far as possible sifted the practical from the purely fantastic and gathered together a presentable list of authors for this space travel issue. Unfortunately our old friend Dr. Theodore von Karman was unable to write for us because of illness, but we are glad to say he is now well on the road to recovery.

*

The attentive reader will hardly emerge with the feeling that the subject of space travel is above his head (in a figurative sense, of course). The possibility of official experiments with space rockets was alluded to already at the end of World War II by the late General of the Army Henry H. Arnold, former Commanding General of the U.S. Army Air Forces, in the conclusions to his final report on the war activities of the U.S.A.A.F., published on November 11th, 1945. And in a memorandum of December 29th, 1948, the late U.S. Secretary of Defense James V. Forrestal stated: " ..... The Earth Satellite Vehicle Programme, which is being carried out independently by each military service, has been assigned to the Committee on Guided Missiles for coordination." It may now be re-called that in April 1949 *Interavia,* in an article entitled: "Castles in and beyond the Air", pointed out: "... Sooner or later the artificial satellites will rotate around the earth, even not without the dimensions and luxury attributed to them by over-enthusiastic journalists ..." What at that time sounded like a dream or Utopia is now about to be realized. Today the picture is a different. Nevertheless, many of the space enthusiasts' dreams will probably remain unfulfilled for many years to come, perhaps for ever, even if their sponsors do firmly believe in them and presented them to the Rome Congress as if they were established facts.

Writing 150 years ago, Johann Wolfgang von Goethe described this mental attitude in a single sentence. When Heinrich Faust, Ph.D., LL.D., M.D. demanded that Mephistopheles should procure fresh jewels for Gretchen—the first set had been "swept away" by a "rascal priest"—Mephistopheles set about his task with reluctance: "*Such lovesick fools away would puff sun, moon and stars into the air, and all to please their lady fair.*"

Many space travellers, like Faust, would sacrifice all the heavenly bodies on the altar of their own pet projects.

EEH

* The object of the research programme for the International Geophysical Year is to improve our meteorological knowledge through simultaneous world-wide observation of all weather factors both from the ground and in the upper atmosphere, including radiation measurements. The I.G.Y. begins on July 1st, 1957, and ends on December 31st, 1958.

Space travel

Our Century will see the Birth of Astronautics

by Professor Gaetano Arturo Crocco, Rome

Born in 1877, the author joined the «Brigata Specialisti» of the Italian Engineers Corp at the turn of the century, holding a leading position in it until 1923. He spent the next few years at the Ministry of Economics as industry representative, was appointed to the University of Rome (chair of aviation) in 1927 and reactivated as a Lieutenant General in the Air Force Engineers Corps in 1928. Five years later he became research chief at the Italian Air Ministry. — G. A. Crocco has been a member of the Accademia dei Lincei since 1919, of the Accademia d'Italia since 1932 and of the Papal Academy since 1936, as well as a corresponding member of aeronautical institutions throughout the world. Finally he is President of the Associazione Italiana Razzi (Italian Rocket Association) in Rome. — Editors.

The roads on land were travelled at increasing speeds once the wheel was invented and supplied with motive power.

The sea lanes were travelled faster and faster once the floating body was invented and supplied with motive power.

The air routes were travelled once the supporting wing was invented and supplied with motive power.

Man's three means of locomotion—land, sea and air—are thus all attributable to the solution of two technical problems, support and propulsion; support to bear the weight of the vehicle; propulsion to overcome the resistance to motion raised by speed and by the support itself.

In all three cases, movement takes place in three essential phases. In the first phase the vehicle accelerates to a given speed; in the second it maintains this speed by opposing a continuous propulsive force to the resistance provided by its motion; in the third phase the vehicle brakes its speed and comes to a standstill.

*

Today, with astronautics, men's minds are seeking to create a fourth type of locomotion—space travel—that will escape from land, sea and atmosphere and navigate in a vacuum. But it should be stressed immediately that an absolute vacuum does not and cannot exist, except in certain privileged regions of the universe. Apart from these regions, in the rest of the universe there is always a residue of interstellar matter of approximately one atom of hydrogen per cubic centimetre.

The resulting density of matter is extremely low, and a spaceship moving among it at astronomical speed, i. e., at the speed of the stars or the planets, can travel for millions of centuries without needing propulsion. Only when a spaceship can move in interstellar space at a superastronomic speed approaching that of light, will it be necessary to overcome the resistance of interstellar matter by means of a propulsive force.

In the case of the interplanetary travel so far envisaged in astronautical engineering, travel that will take place at speeds much lower than that of light, the problem of propulsive force during movement does not arise, since there is no passive resistance. Nor is there any problem of support. As the vehicle is subject only to Newtonian forces of gravitation it will automatically develop at all points of its orbit a centrifugal force equal and opposite to its weight.

But then, what technical problems remain to be solved in space travel when the two typical problems of other types of locomotion, propulsion and support, no longer arise? There remain only the problems of acceleration and stopping, i. e., the first and the third phases. The first phase becomes essentially a problem of launching, the third a problem of braking.

The intermediate phase covering most of the trajectory takes place by inertia, with rockets extinguished, and can thus be called the inertial phase.

The space vehicle must therefore be launched from the ground as, in ballistics, a shell is fired from a gun; i. e., it must be subjected to a purely temporary propulsive thrust which, after overcoming atmospheric resistance and terrestrial gravity, ceases when the vehicle's speed is high enough for the planned space mission.

This notion of temporary propulsive force is the reason for my choosing the expression *ballistic locomotion* and the word *missile* (meaning "object thrown" in Latin) for the vehicle. But the launching of the missile does not need a gun. The propulsive charge is contained within the vehicle from the moment of launching and operates even in an absolute vacuum, as it acts only against itself. *The spaceship must therefore be fitted with a rocket motor.*

*

In essentials, a rocket motor is a power unit consisting of a combustion chamber in which an explosive mixture is burned at a predetermined rate and from which a powerful jet of burnt gases then exhausts. The higher the speed of the jet, the higher the speed it imparts to the vehicle. All progress in rocket engineering lies in increasing the speed of the jet and in controlling its regularity.

Great strides have been made in both these directions. Today the rocket is sufficiently advanced to leave our earth altogether, to open the new era of space travel. This era will have a beginning and an end.

The first step will be the construction of the first circumterrestrial missile, or artificial satellite; the last step that of a manned vehicle to travel through interstellar space.

Between these two extreme points falls the whole technique of rockets and spaceships, the whole science of circumterrestrial and extraterrestrial travel, the whole research into ultimate objects and means of achieving them. The satellite can be achieved shortly; interstellar travel is a much more distant prospect.

The coming International Geophysical Year will see the first step into the future in the form of unmanned instrument stations launched around the earth without human control. Probably America will not be alone in this new international undertaking.

Further steps—in a sense intermediate stages in space travel—will be interplanetary journeys inside our solar system. At the recent 7th International Astronautical Congress in Rome I endeavoured to demonstrate that a round trip from earth to Mars and Venus and back to earth within a year is technically feasible and that a favourable constellation for such a trip will exist in 1971.

*

The Church and Astronautics

Extracts from the address by His Holiness Pope Pius XII at Castel Gandolfo to the delegates to the 7th I.A.F. Congress

On the occasion of the 7th Congress of the International Astronautical Federation which has brought you to Rome this year, you have expressed the desire to associate Us in a sense with your work. We are happy that this should be so and would express Our admiration for the conviction, tenacity and courage of all those who have been advancing step by step during the past fifty years towards the conquest of this vast domain.

On first hearing of your activities and of your Federation's aims, the layman cannot avoid a feeling of astonishment; the very word "astronautics" suggests the idea of fantastic voyages through vertiginous spaces and under conditions of especial danger to the human organism thus projected outside its natural element. There are still many people who feel that a project for such an expedition can originate only in an unbridled imagination with little respect for solid data. Yet even at the beginning of the century the fundamental principles on which astronautics was to be based had already been clearly and logically formulated. It was asserted that a moving object could escape from terrestrial gravity if it had sufficient acceleration, and that this acceleration could be obtained by using a rocket; soon the possibility of manned space travel was also envisaged...

...Today you do not hesitate to tackle the more general problems set by the conquest of interplanetary space; and it even appears from the documents you have communicated to Us that some of you have gone as far as examining the abstract possibility of interstellar travel, which the very name of Astronautics indicates to be the ultimate aim of your work.

Without going into details, it will not have escaped you that a project of such scope involves intellectual and moral aspects which cannot be ignored; it postulates a certain concept of the world, of its meaning and its finality. The Lord God, who implanted in man's heart an insatiable desire for knowledge, did not place any limit on his efforts at conquest when He said: "Subdue the earth" (Gen. 1, 28). It was rather the whole of creation which He offered for the human spirit to penetrate and thus understand more and more profoundly the infinite greatness of the Creator. If hitherto man has felt, so to speak, shut up on the earth and has had to be content with the fragments of information which reached him from the universe, it now looks as if the prospect is opening up to him of breaking these barriers and advancing towards new truths and new knowledge which God has placed in the world in profusion. With mere curiosity or adventurousness as a motive it will never be possible to orientate correctly efforts of such a scope. Faced with the new situations created by the intellectual development of mankind, conscience must take a stand; man should broaden his knowledge of himself and of God, so as to find his true place in the world as a whole and to recognize more exactly the implications of his actions. This common effort by the whole of mankind towards the peaceful conquest of the universe should help to impress more firmly on men's consciences a sense of community and solidarity, so that all should feel more strongly that they are members of God's great family and children of the same Father. To penetrate this truth requires just as much respect for the true, acceptance of the real, and courage as does scientific research. The most daring explorations of space will merely introduce a new ferment of dissension among men unless they are accompanied by deeper moral reflection and a more conscious attitude of devotion to the higher interests of mankind.

We hope sincerely that the present Congress will advance you on your long and difficult road and would wish above all that the scope of the spiritual discoveries made will be in no way inferior to the scientific progress.

In asking for you the protection and favours of God, who made the universe for man so that he might know and love Him, We bestow on you, your families and your associates, in His name, Our Apostolic Benediction.

His Holiness Pope Pius XII receives the astronauts in audience. To the right of the Pope, Professors von Kármán (with black tie) and G. A. Crocco (with chain), left General Bergeron (profile) and F. C. Durant (behind).

And what of interstellar travel, the astronaut's ultimate goal?

Before we can discuss this subject seriously we must basically change our thinking, from Newton's to Einstein's laws of mechanics.

If a spaceship succeeded in penetrating non-gravitational space and—despite the resistance of interstellar matter—in moving in it at speeds approaching that of light, then even other solar systems would in principle be accessible to us.

At the same time, however, all lengths on board the spaceship would shrink, time (as measured by the occupants' pulses or the oscillations of the chronometer's balance) would dilate, masses would grow. For example it can be imagined that, at a certain speed of the spaceship, one day on board would be equal to 365 days, or a whole year, on earth. Thus, on returning to earth, our astronauts could meet the tenth or twentieth generation of their own descendants.

Whether such speeds can ever be achieved, or whether they will be prevented by the resistance of interstellar matter or the radioactive heating of the spaceship and its crew, is another question. In theory, at any rate, we are justified in thinking of these speeds.

*

Are we justified, however, in taking the last logical step and assuming a spaceship speed exactly equal to the speed of light? I do not think we are. For that would take us outside the realm of physics into the realm of metaphysics. Man cannot, by travelling at the speed of light, make himself immortal in this life; only his non-material soul is immortal.

What is light after all?

Light was created on the first day of Genesis and was the most miraculous expression of creation since it gave the universe a measure of time and distance. God himself saw that it was good.

Later—says Genesis—God created man in His image and likeness and gave him a sign of His divinity.

Now I like to imagine that this sign of divine being was a ray of light. Then the human spirit would be neither more nor less than a ray of light incorporated in the living matter. Its personality is determined by the wave length. And there is an infinite number of wave lengths.

Finally I like to think that on leaving its material hull the human spirit resumes its astral and divine nature and is destined to travel through the universe at the speed of light, a perennial symbol of immortality and eternity.

Space travel

The 7th International Astronautical Congress in Rome

Congress hall (at the Esposizione Universale di Roma) and Contin MR. 27 rocket.

The ineradicable impression made on any unbiassed observer listening to the 44 brief lectures or examining the nearly 5 lbs. of printed matter issued by the 7th International Astronautical Congress was that of a dream world. — A rocket with a launching weight of 10, or perhaps 100, tons? That could at best be of interest to the military, but certainly not to a space traveller. Much better take several hundred three-stage rockets of 10,000 tons each and build a "city in space" somewhere about the year 1971. — How nice it would be to present not only the earth but also the moon with artificial satellites, which could be observed through a twelve-inch telescope! All that is needed for this is a single multi-stage rocket weighing roughly 450 tons and a control system twenty times as accurate as the one planned for the *Vanguard* earth satellite. — Bravo, Colonel F. K. Everest, who flew the Bell X-2 rocket aircraft (since crashed) in July this year at a speed of 2,500 m.p.h., or slightly more than one kilometre a second. Does not this justify us in thinking already of a speed some 300,000 times higher, at which we can some day travel through the whole Milky Way? . . .

It should, however, be added that not all the lecturers allowed their thoughts to fly through interplanetary or interstellar channels. A good half of them kept at least one foot firmly on this earth and described either interesting details of rocket engineering and concrete medical research work, or discussed the United States earth satellite programme for the International Geophysical Year. *Not only sun, moon and all the stars, but also our own planet came in for its share of attention.*

For the first time in the history of astronautics a space travel project is about to be put into practice: model of the 20-inch spherical satellite for *Project Vanguard* at the Hayden Planetarium, New York.

1. Earth satellites

For the first time an international astronautical congress had the advantage of being able to point to a space travel programme that is not only practical but even about to be put into operation. As *F. C. Durant,* outgoing President of the International Astronautical Federation, put it, we are now in "the year minus one or minus two of the space travel era." Only a world disaster could prevent the United States from launching a whole series of dwarf satellites, with the aid of *Vanguard* three-stage rockets, from the southern tip of Florida during the I.G.Y. and setting them to circle the earth on an elliptical orbit.

Special interest was shown by the Congress delegates in the paper read by *N. E. Felt Jr.* (The Glenn L. Martin Company), who reported on the structure and dimensions of the *Vanguard* satellite vehicle (see box on page 958). For many space travel enthusiasts, however, the lecture will have been a disappointment in that it revealed that a total launching weight of no less than 22,600 lbs. is required in order to accelerate a miniature satellite of only 21.5 lbs. to orbiting speed. This gives a payload ratio of 1 : 1,050, whereas hitherto it has been assumed that very much more favourable figures, such as 1 : 500 or 1 : 200, could be obtained.

Details of the satellite movements were discussed by *J. DeNike* (Glenn L. Martin) and *Dr. W. B. Klemperer* (Douglas Aircraft Company), both engineers. While DeNike spoke on the effect of the earth's oblateness and of the earth's atmosphere on the movements of the artificial moon, Dr. Klemperer showed that a satellite that was not a perfect sphere, for example an ellipsoid such as our natural moon, would carry out pendulum-like oscillations (librations), which can be calculated. Other excellent papers on satellite orbit calculations were read by *Dr. Ing. J. Kooy* (Royal Netherlands Military Academy) and *Dr. H. Krause* (Institute for the Physics of Jet Propulsion, Stuttgart). *Professor S. F. Singer* (one of the authors in the present issue) announced methods of estimating the temperature of earth satellites, *Professor L. Whipple* (Smithsonian Institution) spoke on preparations for optical and radio tracking of the I.G.Y. satellites, and *Dr. Ing. F. Romano* (Contraves Italiana) expatiated on the possibility of protecting manned satellites, which in his view might some day be used as weapons, from radio or visual detection.

On the other hand, *D. Romick* (Goodyear Aircraft Corp.) entered the realm of "technically based speculation" with the concept of a large manned—not to say populated—satellite, the *Meteor* (abbreviation for "Manned Earth-satellite Terminal evolving from Earth-to-Orbit Rockets"), which he backed up with structural and operational details in the form of drawings and diagrams, and a time schedule. Though the lecturer stressed that he was not putting forward any final project but merely proposing a basic concept which could be reduced in size to any extent desired (down to one tenth of the original), his ideas still appear entirely fantastic even when so reduced. Romick's original project calls for three-stage feeder rockets each with three delta wings and a launching weight of 9,000 plus 1,250 plus 140 short tons for a 35-ton payload, construction of a drum-shaped "city in space" 2,500 ft. long and 1,000 ft. in diameter, to be put together from the final stages of the rockets and parts of their payload; orbit altitude 500 miles; development to begin in 1959, construction in 1964 (feeders) and 1968 (satellite); beginning of operation, 1971.

2. Sun

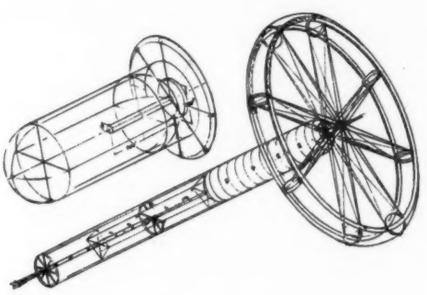
The sun, its radiation and its planetary system was the subject of a number of papers, the three most interesting of which are discussed below.

Dr. med. H. Strughold (School of Aviation Medicine, Randolph AFB), in a paper read for him by his colleague Dr. S. J. Gerathewohl, examined the so-called ecosphere of our planetary system, that is, the zone surrounding the sun in which any form of plant or animal life is possible. The former requires biologically supportable temperatures and the presence of liquid water, the latter a percentage of oxygen in the atmosphere as well. Dr. Strughold's conclusions are distinctly sobering for would-be planetary colonizers: "Beyond Venus—on Mercury—it is too hot; beyond Mars—from Jupiter to Pluto—it is too cold... Mars is a very dry planet with perhaps sufficient moisture to support lower forms of life. In the Venusian atmosphere water has not yet been detected. The atmosphere round Mars contains oxygen compounds such as carbon dioxide, but no free oxygen; the same applies to Venus. The zone not entirely inimical to life stretches at most over 5 percent of the distance between the sun and Pluto, and our earth lies in its "golden mean." Some of the space travel stalwarts might, however, find a certain comfort in the assumption that among the (estimated) 100 trillion other suns and stars in the whole universe there are perhaps 100,000 "bioplanets" capable of supporting life and hence—in principle at least—suitable for colonization. "Yet all of this", said Dr. Strughold, "is, and probably must forever remain, a matter of delightful speculation."

The sun's radiation and its use as a source of energy for space travel purposes were discussed by *Dipl. Ing. K. A. Ehricke* (Convair Division, General Dynamics). The sun's energy would be of particular value as a source of power for spaceships travelling at low thrust far outside the earth (and starting from satellite orbits), but could also be used to power satellite stations. In order to collect the sun's energy, Ehricke proposes the use of large plastic balloons with transparent envelopes roughly 0.001 inch thick, one half of whose inner surface would form a hollow mirror. The sunlight reflected on the centrally placed heating element would heat up hydrogen, which would then be ejected through rocket nozzles.

Finally mention should be made of the paper by *Professor G. A. Crocco* (University of Rome, and many scientific academies), who was the only lecturer to speak of the possibility of interplanetary travel, namely, to the two nearest planets, Mars and Venus. Crocco suggests that this journey should begin in June 1971, when there will be a favourable constellation for its completion within a year: the "hop" to Mars would then take 113 days, Mars to Venus 154 days, and Venus back to earth 98 days.

This is how the Akron engineers imagine the foundation stone for the "city in space" will be laid: the first two final stages of ferry rockets are placed nose to nose and joined with rings and stringers. A third ferry (foreground) is apparently awaiting its turn (drawing by Russell Lehmann).



For operation in 1971? Drawing of the *Meteor* supersatellite projected by Goodyear engineers of Akron, Ohio, and consisting of a stator 2,500 ft. long (diameter 1,000 ft.) and a rotating "residential wheel" 1,500 ft. in diameter. *Right*, building the inner stator tubes and the hub for the "residential wheel" in space ... about 500 miles above the earth's surface (FR: ferry rocket).

The supply base for the "city in space": three-stage rockets with a launching weight of 10,390 short tons (for a payload of 35 tons each). Each stage is equipped with wings, tail and control system (for landing after completed mission), and the two lower stages also have dozens of jet engines.

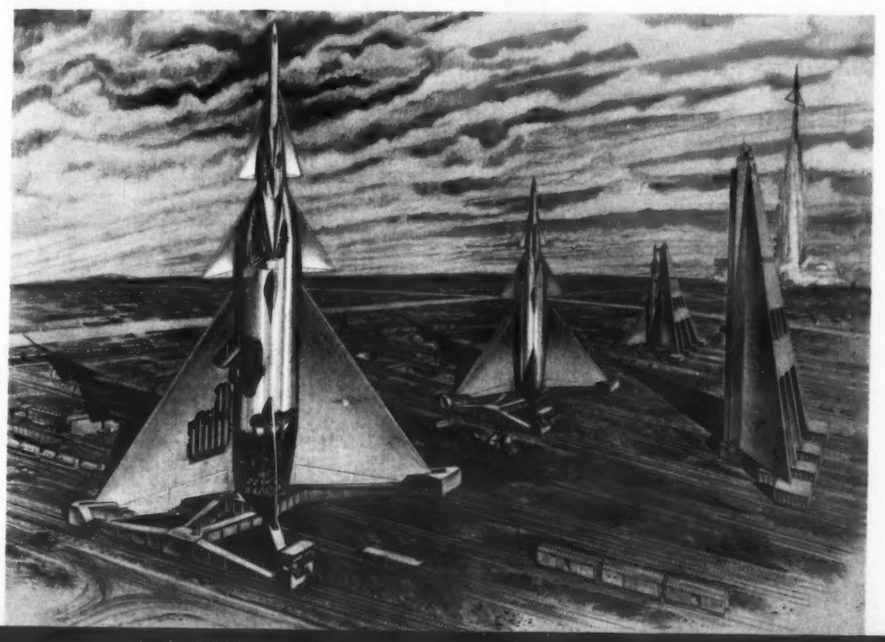
3. Moon

Despite its popularity with the public, the moon was the subject of only four of the 44 Rome papers. *R. W. Buchheim* (Rand Corporation, Santa Monica) examined the possibility of circling the moon with an artificial satellite which would be visible from the earth. He came to the conclusion that such a moon's moon would have to have a weight of approximately 500 lbs. and would thus need a multistage transport rocket weighing some 450 tons. In addition extremely close tolerances for departure speed ($\pm$ 15 ft./sec) and departure angle ($\pm$ 0.3°) would have to be observed. *A. Boni* (Italy) proposed that relatively simple unmanned "moon messengers" armed with television cameras should be sent out, which "would not cost much more than the American I.G.Y. satellites". Finally the Americans *N. V. Peterson* spoke on the minimum size of manned moonships, and *K. R. Stehling* on small lunar rockets.

4. And all the stars ...

Dr. Ing. E. Sänger (Research Institute for the Physics of Jet Propulsion), the promoter of the photon power plant[1], seriously discussed, in the confident expectation of further rapid progress in atomic physics and on the basis of Einstein's Special Theory of Relativity and

[1] cf. *Interavia* No. 11, 1953, p. 642.



its "time dilatation", the possibility of exploring the whole Milky Way. He came to the following interesting conclusions:

"We assume the limit case of a rocket vehicle with complete radiation of mass, in which the propellant masses carried aboard the vehicle are transformed entirely into photons or neutrinos, anti-neutrinos, gravitons etc. and are thus radiated in a pre-selected direction at the speed of light . . . (also) an acceleration equal to the earth's normal acceleration (9.81 m/sec) over all imaginable astronomic distances . . ."

(In view of the dilatation of time) ". . . the length of a human life would . . . be sufficient to travel round a whole static universe (approx. 3,000,000,000 light years). Whether our own solar system would still be in existence on the crew's return is more than doubtful, since more than 3,000,000,000 earth years would have passed . . .

"It is definitely not true that journeys to the fixed stars would take so many years that several generations would be born, grow up and die . . . The infinite universe is small enough to be open to each one of us personally right to its farthest limits; everything is accessible to man."

5. Space medicine and space law

Back to earth . . . with the papers by the aviation and space travel physiologist *Dr. phil. S. J. Gerathewohl* (School of Aviation Medicine, Randolph AFB) and the biologist *Major (U.S.A.F.) D. G. Simons* (Aero Medical Field Laboratory, Holloman Air Development Center).

Dr. Gerathewohl reported on the personal experience of 16 volunteers during brief periods of weightlessness in shallow dives or parabolic, upward curving flight paths. The test persons were carried in the second seat of a Lockheed T-33 jet trainer (in which weightlessness was achieved for periods of 10 to 30 seconds) or in a two-seat Lockheed F-94 all-weather fighter (weightlessness for up to 47 seconds). Their impressions of free hovering in space were very varied: Most of the men found the state of weightlessness comfortable; a number of persons reported sensations of motion such as falling, hovering and turning. A small group experienced discomfort and showed the characteristic symptoms of air and sea sickness. There appear to be considerable differences between individuals as regards both tolerance and adaptability. If suitable persons are chosen, the introduction of a permanent acceleration or "quasi-gravity" in spaceships will not be necessary.

Major Simons spoke on the biological effects of primary cosmic radiation, one of the most greatly feared dangers of space travel. To investigate these effects, the U.S. Air Force sent some 25 balloons carrying test animals—

Dr. H. Strughold and Dr. S. J. Geratewohl (both of the U.S. Air Force's School of Aviation Medicine) in front of one of the Lockheed T-33 jet trainers at Randolph AFB, in which pilots achieved a state of weightlessness for periods of 30 seconds.

mice, guinea pigs, monkeys—up into the stratosphere, reaching heights of more than 20 miles and "exposure times" of up to 30 hours. One monkey, still alive, even spent 63 hours at altitudes above 115,000 ft. The animals were, of course, placed in heat-insulated pressure containers (of fibreglass). They kept warm by animal heat and were supplied with oxygen while the carbon dioxide was absorbed; air humidity 80%. — A particular sign of primary radiation was the graying of the hair in black mice, which occurred to a much greater extent than had been expected. Nevertheless Simons concluded that there would be no danger of serious damage to humans through primary cosmic radiation during exposures of less than 24 hours. Studies of longevity and further progress in cancer research might, however, change this result.

These two reports were followed by the Congress's final paper, read by the well-known aviation medical expert *Prof. T. Lomonaco* (Centro di Studi e Ricerche di Medicina Aeronautica, Rome) on physiopathological effects in space travel.

While the biologists and medicos could produce some concrete results of their researches, the space travel jurists are still empty-handed. With Accursius' legal principle, which still applies to aviation, "Cuius est solum, eius est usque ad coelum"[2], every space travel project could be throttled at birth. Fortunately President Eisenhower has declared the American I.G.Y. satellites, which will cross all countries between latitudes 40° north and 40° south, to be a purely civil project, so that no serious objections to the programme have so far been raised. What the various governments will say, however, when the first manned satellite vehicle is ready to take off may be another question.

In the face of this situation, the two legal experts who spoke in Rome, *A. A. Cocca* (Argentina) and *A. G. Haley* (United States) merely argued that something must soon be done to reach international agreement. The jurists should not allow themselves to be outrun by the engineers. A. A. Cocca combined this appeal with the—interesting—demand that Einstein's Special Theory of Relativity should also be applied to law: "Why should not law too be studied in the fourth dimension, since it applies to man, who is a four-dimensional being?"

*

One aspect of the Rome Congress that was particularly pleasant was the external setting. It must be admitted that, however enthusiastic the space travellers may get in theory about moon landscapes or planets with ammonia atmosphere, in practice they never fail to hold their meetings in pleasanter parts of the universe: Zurich in 1953, Innsbruck in 1954, Copenhagen in 1955, Rome in 1956.

The Congress was opened by Professor G. A. Crocco, President of the host "Associazione Italiana Razzi". His speech was followed by addresses by Senator Tupini, Mayor of Rome, and Frederick C. Durant, officiating President of the International Astronautical Federation. Altogether 23 space travel and rocket research associations from 22 countries[3] were represented, with a total of approaching 350 persons including guests.

Among the many well-known personalities in the audience there were Professors Ackeret (Zurich), Ambrosini (Rome), Broglio (Rome), Brun (Paris), Casiraghi (Genoa), Eula (Rome), Eugster (Berne), Gabrielli (Turin), Kaplan (Los Angeles), von Karman (Paris), Pirquet (Vienna), Sedov (Moscow), Zarankiewicz (Warsaw), Generals Alippi (Italy), Bergeron (France), Bruno (Italy), Davis and Flickinger (U.S.A.), Mancinelli, Pezzi and Raffaelli (Italy); engineers Cleaver (London), Gatland (Kingston-on-Thames), Gerber (Zurich), Müller (Buffalo, N.Y.), Shepherd (Chilton, Berks.), P. A. Smith (Washington, D.C.), Staats (Bremen), Steinhoff (Holloman AFB). This list naturally makes no claim to be complete.

On the final day of the Congress a new I.A.F. Committee was elected: Dr. L. R. Shepherd (United Kingdom) becomes Chairman; the four Vice-Chairmen are General P. J. Bergeron (France), F. C. Durant (United States), A. Sedov (U.S.S.R.) and T. Tabanera (Argentina). The I.A.F. Congress is to be held in Barcelona from October 7th to 12th, 1957.

Special highlights of the Rome Astronautical Congress were the reception of delegates and guests by Pope Pius XII at Castel Gandolfo (see "The Church and Space Travel") and the humorous speech by Professor Crocco at the farewell banquet in Palazzo Barberini. Alluding to Einstein's theory of time dilatation near the speed of light, he concluded: "It was a pleasure for me to meet you all yesterday in Copenhagen and to see you here today in Rome . . . Goodbye, *until tomorrow in Barcelona.*"

[2] "The possession of land implies possession of the space above it, to the very Heavens themselves"; cf. *Interavia* No. 4, 1954, p. 238.

[3] Argentina, Austria, Belgium, Brazil, Canada, Chile, Czechoslovakia, Denmark, Egypt, Eire, France, Israel, Italy, Poland, Spain, Sweden, Switzerland, U.K., U.S.A., U.S.S.R., West Germany, Yugoslavia.

The I.G.Y. Rocket and Satellite Program[1]

By Prof. Joseph Kaplan,

Chairman, U.S. National Committee for the International Geophysical Year, National Academy of Sciences,

University of California at Los Angeles.

The satellite program for the International Geophysical Year (I.G.Y.) represents a new departure in man's continuing effort to increase his knowledge of the physical universe. Its significance for science, in permitting man to reach into the upper atmosphere to gather data needed for an understanding of his environment, cannot be over-stressed. It is one of the boldest, most imaginative steps taken by man, and it represents the first stage in his acquisition of direct knowledge of the universe far beyond the earth's surface and far beyond the scope of aircraft, balloons, and even conventional research rockets.

The primary objective of the program is, then, the acquisition of knowledge about the outer atmosphere and the particles and radiations impinging upon it from the sun, the stars, and the interplanetary medium. For centuries man was limited in his exploration of outer space to the observations he could make from the surface of the earth. The envelope of atmosphere surrounding the earth has seriously restricted man in his understanding of particles and radiations. Direct observations are needed, but direct observations can only be obtained by actually reaching out beyond the lower, dense portions of the atmosphere.

Rockets are tools to reach directly into the outer atmosphere, providing data not only of great intrinsic value but information that can be correlated with the vast quantities of ground based observations.

[1] Extracts from a paper read at the Barcelona conference on September 11th, 1956, to prepare for the International Geophysical Year.

The U.S. rocketry program calls for the firing of some 200 research rockets during the IGY, with about 20 additional test rockets to be fired before the IGY begins. The types of rockets to be used will include the *Aerobee,* the *Nike-Cajun,* the *Nike-Deacon,* and *rockoons.*[2] This program, since it does not represent a separate discipline, has been designed to complement various studies. Thus, there will be experiments in atmospheric structure, atmospheric composition, radiation studies, particle studies, and ionospheric and geomagnetic measurements.

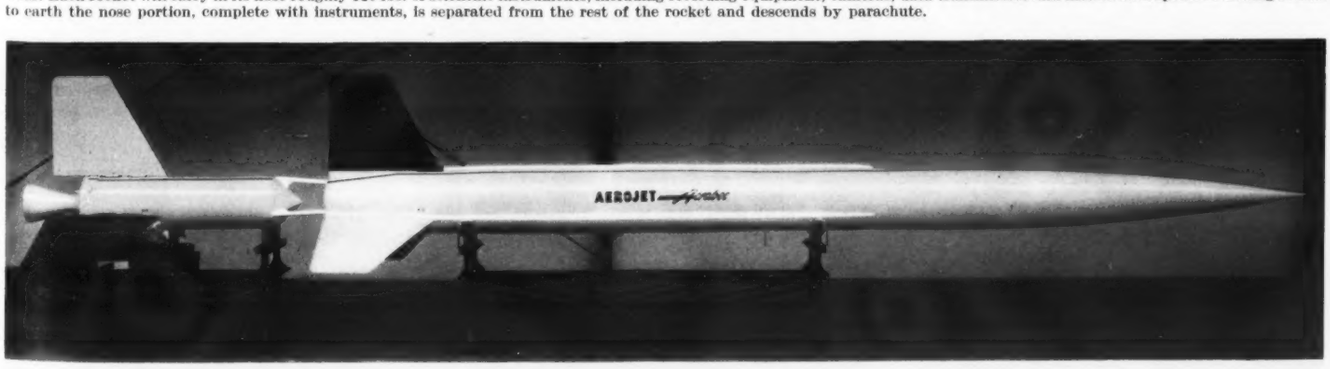
Many rockets will carry out several experiments, so that the total number of rockets that will be fired does not give an accurate picture of the scientific importance of this project. For example, there will be three types of experiments from ship-board rockoon launchings from the Arctic to the Antarctic. Rockoons carrying cosmic ray equipment will be launched about every five degrees of latitude to provide a cross-section of cosmic ray intensity at various geomagnetic latitudes. The second experiment involves sending rockoons into the ionosphere in the region of the geomagnetic equator to make direct observations of the presumed equatorial current. The third group of experiments involves the study of so-called soft radiation above 50 kilometers in the southern auroral zone. This last group will be coordinated with simultaneous observations in the northern auroral zone.

[2] *Nike-Cajun* is the designation of a N.A.C.A. two-stage solid-propellant rocket consisting of the booster from the *Nike* and a converted high-performance rocket motor. It can carry 40 lbs. of instruments to altitudes of 100 miles (burnout velocity more than 4,000 m.p.h.). The *Nike-Deacon* is probably a similar combination, and *rockoons* are rockets launched from stratospheric balloons. — Ed.

To promote inter-discipline and international cooperation, the details of the U.S. rocket sounding program have been published in the proposed program of the U.S. National Committee. We have also published as firm a schedule of rocket firings as it is possible to make. Rockets are limited however, to a narrow zone of the atmosphere, ascending and descending almost vertically, and to short intervals of time. In spite of these limitations, research rockets continue to represent a valuable and unique tool, particularly within the region between the maximum range of sounding balloons—about 100,000 feet (30 kilometers)—and the minimum altitude that can sustain satellite flights—roughly 200 miles (320 kilometers). The advantages of satellites are that they provide a vehicle for carrying instruments above the major portion of the atmosphere for an appreciable length of time and that they can traverse a broad expanse of the high atmosphere.

The I.G.Y. satellite program thus affords an unusual opportunity for the world's geophysicists to acquire information about the upper atmosphere. As in other I.G.Y. programs, this opportunity is a broad one: the nations of the world will not only observe the satellite but will participate in the scientific program. Extensive international participation will yield maximum advantage from the endeavor.

American research rockets of the Aerojet *Aerobee* and *Aerobee-Hi* models will make many more ascents to altitudes of some 190 miles during the International Geophysical Year. Each rocket will carry in its nose roughly 120 lbs. of scientific instruments, including recording equipment, cameras, data transmitters and meteor microphones. During return to earth the nose portion, complete with instruments, is separated from the rest of the rocket and descends by parachute.



Space travel

A preliminary list of advantageous satellite observation and measurement sites has been made by the U.S. National Committee, calling for some thirteen optical observation stations and some ten radio observation stations forming a picket line along the 75-degree meridian. Emphasis has been placed on a north-south line of stations, in view of the launching aspect, with some added stations to provide longitudinal coverage. These are but suggestive. It is hoped that many more stations will be established by the nations participating in the I.G.Y.

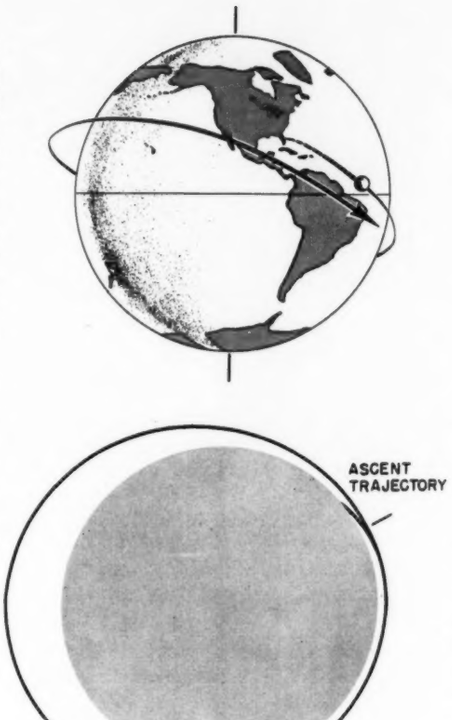
It is gratifying that the I.G.Y. satellite program has been established as a civilian program of broad base, resting upon the contributions of many investigators of many nations. And it is most fitting that the results of these investigations now make possible, during the I.G.Y., the accomplishment of this long-desired objective, providing a tool that will permit us to measure directly, over long periods of time and over an appreciable expanse of the outer atmosphere, those phenomena about which man needs to know so much more.

*

Within the United States, broad participation of American scientists in this endeavor is being effected by the National Academy of Sciences, which established the U.S. National Committee for the I.G.Y. This Committee, with its subcommittees and panels, is charged with the responsibilities for planning, directing, and executing the U.S.I.G.Y. effort, embracing every discipline and area of our I.G.Y. participation. The Government has cooperated extensively in the realization of the program, both program-wise and fiscally.

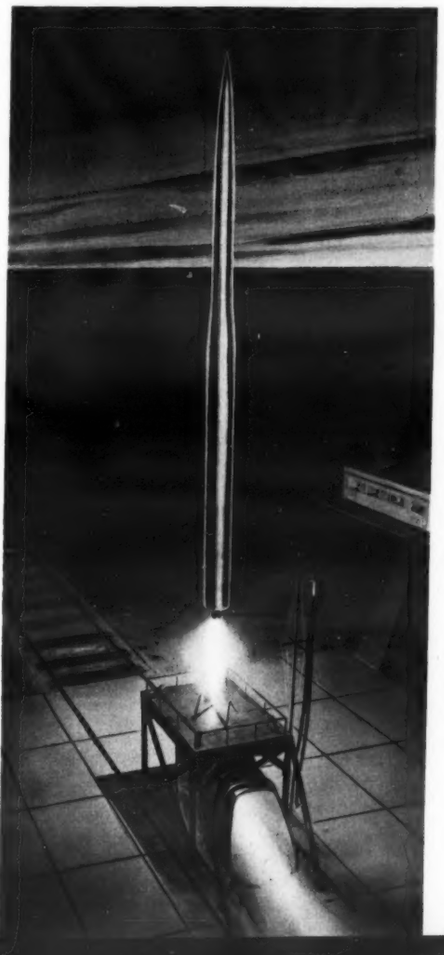
In the development of the satellite program and assignment of responsibilities, the National Academy's Committee recognized that there were two major areas of activity. First, there were the engineering problems associated with the design and construction of the propelling rocket vehicles, their launching, and associated logistics problems. Second, there were the problems of the scientific program, and here we had in mind, first, the radio and optical ground observation and measurement programs, and, second, the various experiments, both ground based or contained within the satellite itself.

In recent years significant scientific studies of the upper atmosphere have been conducted by the civilian laboratories of the Department of Defense and their industrial and university contractors, using research sounding rockets. The experience and competence of these groups led the Committee to request of the Government that this talent be utilized in the design, construction, and launching of the rockets. This responsibility has been assigned to the Naval Research Laboratory which is in charge of the contributions of the three military services and various industrial contractors.



Elevation and plan view of the *Vanguard* satellite orbit. Probably launched from Patrick AFB, Florida, the first American satellites will cross the Equator at an angle of 40 degress. Their orbits will be elliptical, with a perigee of roughly 200 miles (above the ground) and an apogee of 1,400 miles.

U.S. Navy drawing to illustrate the launching of a *Vanguard* three-stage satellite rocket.



The high-precision optical observation program in the United States has been assigned by the Committee to the Astrophysical Observatory of the Smithsonian Institution. The precision radio observation program has similarly been assigned to the Naval Research Laboratory, which has developed the system and the equipment. Plans have been developed for participation of a number of private and public laboratories in the development and design of experiments and instruments.

Present plans call for the satellite to be launched from the east coast of Florida at Cape Canaveral. A three-stage rocket will be used to place it on orbit. The rocket will be about 72 feet (22 m) long and will have a maximum width of 45 inches (115 cm). It will be finless, using internal controls for guidance.[3]

The first satellite will be spherical in shape, about 20 inches (50.8 cm) in diameter, and will weigh approximately 21.5 pounds (9.8 kg). About half of this weight will be required for the instrument itself; the other half will be left for the various instruments, including the telemetering system.

The satellite's orbit will permit it to revolve about the earth in an apparent latitude range of about 40 degrees on either side of the equator. As it revolves about the earth once in slightly more than an hour and a half, the earth will rotate beneath. Since the earth rotates about its axis once every 24 hours, it will have made about one sixteenth of a revolution each time the satellite orbits once completely.

In this orbit between 40 degrees north and 40 degrees south of the equator, the satellite's instruments will be able to record observations over an appreciably broad expanse of the high atmosphere. This 80-degree coverage will permit many scientists of a large number of nations to take measurements and to make observations. The U.S. National Committee hopes that some satellites, after the initial ones, may be placed in other orbits so as to permit scientists of additional nations to participate in the study.

Precision in determination of the orbit of the satellite as it moves in its elliptical path from between 200-300 to perhaps 800-1,500 miles (320-485 to 1,300-2,400 km) from the earth is necessary, therefore, to the achievement of the planned experiments. Plans call for tracking, observation, and measurements, using both optical and radio methods. One of the difficulties in the initial optical acquisition of the satellite is the problem of atmospheric conditions. Extensive cloud cover, for example, would minimize the chance of optical acquisition. Here the radio system can play an important part.

*

Radio observations will employ a system developed by the Naval Research Laboratory. It is a precision, several-component system known as *Minitrack*. Ground stations using the

[3] For further details see box on page 958. — Ed.

Minitrack will include a precision multiple antenna array and an extensive electronics installation, requiring an operating staff of several technicians. The expected precision of observations is about three minutes of arc under normal conditions with improvement to a precision of 20 seconds of arc for observations at small zenith angles, or for night operation. The U.S. National Committee plans to install a limited number of stations with this type of equipment.

A second radio tracking system, called the *Mark II Minitrack,* is of lower precision but still of great value because of its adaptability to extensive use. A broad network of such stations would contribute appreciably to the program, particularly in the acquisition and tracking of the satellite.

In terms of minimum north-south chain of stations, intended to insure radio observations, and in terms of necessary spacing (taking economic factors into account), the Committee believes that the following station sites would be desirable: Santiago, Chile; Antofagasta, Chile (with optical observation station); Panama; Antigua, British West Indies; Havana, Cuba; Jacksonville, Florida, U.S.A.; Washington, D.C., U.S.A.; San Diego, California, U.S.A. Plans for the cooperative establishment of these stations are underway. Additional stations are desirable and it is hoped that many nations will participate in the radio tracking program, using both the *Minitrack* and the *Mark II Minitrack* systems.

Optical observations of the satellite can be effected by three types of programs. The most precise optical observations will be made using a modified Schmidt camera developed at the Smithsonian Astrophysical Observatory. Continuous strip film will simplify the problem associated with following the satellite. To provide accurate timing, crystal clocks will give a signal for photography simultaneously with the satellite. Time must be read to the millisecond. Before the Schmidt cameras can be employed, however, the path of the satellite must be known to a precision of about three degrees . . . so that preliminary sighting positions can be established. The radio tracking system will provide this information, but to provide for the remote chance of radio failure in the satellite a network of organized volunteer observers will be used . . . By placing binoculars on fixed mounts and employing a group of such installations disposed so as to cover a large region of the heavens, with good data as to position of the installation, timing of observations, and critical review of the observations by scientists, a major contribution to the overall program is possible.

In the United States such organizations as the American Association of Variable Star Observers are organizing their members to serve as teams of observers. These groups will receive their instructions from the Smithsonian Astrophysical Observatory and the data gathered by them will be collated by that Institution.

John T. Mengel, head of the *Project Vanguard* tracking and guidance branch at the Naval Research Laboratory, with the miniature 10-milliwatt transmitter for the artificial earth satellites (in his right hand) and its gold-plated aluminium container (left hand).

*

One of the most important sets of experiments in the earth satellite program relates to observations, measurements, and calculations which can be made from ground stations. Here both radio and optical observation stations play significant roles. The following are three areas of study that can be conducted:

1. *Air density:* Very little is presently known about the density of the upper atmosphere. From the geometry of the satellite's course and observations of its flight, calculations can be made of the air density.

2. *Composition of the Earth's Crust:* The satellite orbit will have a basic periodicity with perturbations dependent upon local non-uniformities in the gravitational field. Careful observations of the orbit and its variations will permit calculations of mass-distribution in the earth. This, in turn, should yield information about the composition of the crust.

3. *Geodetic Determinations:* Determinations similar to those noted above will provide data about the oblateness of the earth. Synchronized observations may permit improvements in determinations of longitude and latitude.

*

In addition, the satellite affords a unique tool for observations of atmospheric and cosmic phenomena not directly susceptible to measurements on the earth:

1. *Temperatures:* Measurements of temperatures within the satellite and at its surface will be made. The heat within the satellite is derived from solar radiation, the power supplies, thermal radiation emitted by the earth, and a very small amount from friction.

2. *Pressures:* The satellite shell will be air-tight and may contain an inert gas. Pressure gauges will be used to measure pressures during the satellite's life in order to check on leakages and in connection with possible meteoric effects.

3. *Meteoritic Particles:* Small meteoritic particles, a few thousandths of an inch in diameter, are constantly impinging upon the earth's atmosphere. Estimates as to the quantity reaching the earth's surface vary. These micro-meteorites are believed to contribute a measurable amount to ionizing the atmosphere in the E-region (about 60 to 90 miles above the earth). With the use of simple impact detectors these micro-meteorites can be observed. Moreover, measurements of pressure within the satellite will reveal meteorite penetration and some information on size.

4. *Ultraviolet Radiation:* Much of the radiation from the sun is masked from the earth by the atmosphere. This is particularly true of the ultraviolet radiations in the Lyman-alpha region. The satellite offers an opportunity to observe this radiation on a long term basis and thereby to determine the influence of solar flares on its emission from the sun.

5. *Cosmic Rays:* Cosmic rays have high energies and there are variations in their energy content. Because the earth's magnetic field deflects these particles, only those with the highest energies penetrate the mid-latitudes. Many of the low-energy particles are absorbed in the earth's atmosphere, and observations of cosmic rays are generally of "secondaries." The satellite will permit direct studies of primary cosmic rays above the masking atmosphere.

*

It is fitting that this conference and its working groups have met to discuss our cooperation in the satellite program. I have tried in these remarks to outline our progress to date. Much has been accomplished. Much more remains to be done, not only in the scientific problems of placing the satellite on orbit, but also in making certain that its full potential is realized. I hope that our discussions here will lead to man's fullest utilization of this new tool, even in these first steps.

*

At the present time some 50 nations are formally participating in the I.G.Y. program and additional nations are expected to participate or to cooperate in the world-wide effort during 1957-58. The I.G.Y. satellite program is one part of this unprecedented, cooperative, international effort. But the earth satellite is unique in one sense: All the other disciplines to be investigated during the I.G.Y. represent, in one form or another, extensions of existing work. They are unprecedented in scope and intensity; the results to be achieved may well extend man's knowledge of the physical universe immeasurably. The satellite program, however, is revolutionary. Nothing like it has ever been before. The initial step that it represents, limited though it may be in terms of man's aspirations, is an historic event without parallel.

Space travel

The Artificial Earth Satellite – Past, Present and Future

By Dr. phil. S. F. Singer, Associate Professor of Physics, University of Maryland

The beginning of the "space age" is unlikely to upset seriously a world which is by now thoroughly conditioned to the idea. In the following article, the author, known for his design of the small instrumented MOUSE satellite (cf. *Interavia* no. 7, 1955), discusses how satellite experiments lead to a better scientific understanding of our environment, which may have important consequences for our economy and way of life. – Editors.

Nearly 300 years ago Sir Isaac Newton formulated the laws of celestial mechanics to explain the motion of the earth and planets, and of the earth's natural satellite, the moon. Now after centuries of watching these laws in operation we will give up our role as passive observers to test these very same laws on a man-made object, an artificial satellite.

Need for Satellites as Scientific Research Tool

The idea of an artificial earth satellite is many years old, although generally in the form of a manned space station. The concept of a small *instrumented* satellite to be used for scientific research developed only in recent years. Perhaps this is natural enough. The early thinking was done by men coming from the field of aeronautics, or by space flight enthusiasts; in all of these disciplines a manned vehicle seems to be the basis. Since World War II, however, the rise in the science of radio, of electronic instrumentation, and the initiation of upper atmosphere explorations with rockets have focused attention also on an instrumented *unmanned* satellite.

Again this is natural enough. While rockets provide the opportunity for carrying scientific equipment to extremely high altitudes, the total time spent in the upper atmosphere is only of the order of minutes, and they can explore only at a given location of the earth's surface at any one time. The idea of a satellite vehicle which would stay up for many days or months is very appealing to anyone who has gone through the effort of preparing a large number of instrument-carrying rockets, who has launched them at points stretching from the equator to the Arctic, and who has watched them disappear forever after providing only a few minutes worth of data. Not only do we receive an extension in time for the data, but also a large geographic coverage. These considerations then formed the impetus in the thinking behind the small instrumented artificial satellites soon to be launched.

It was fortunate that a clear justification could be given for such a small "minimum" satellite because it represented also a project attainable with present rocket techniques. In other words, a satellite weighing a few pounds is technically feasible today, while a manned space station is not.

The advantages of minimum satellites to various types of geophysical research became so apparent that during the summer of 1954 several international scientific bodies adopted resolutions endorsing the construction of an artificial satellite. The resolution of most immediate interest is the one adopted on October 4th, 1954, by a Special Committee for the International Geophysical Year (CSAGI) which met in Rome. "In view of the great importance of observations during extended periods of time of extraterrestrial radiations and geophysical phenomena in the upper atmosphere, and in view of the advanced state of present rocket techniques, CSAGI recommends that thought be given to launching of small satellite vehicles, to their scientific instrumentation, and to the new problems associated with satellite experiments, such as power supply, telemetering, and orientation of the vehicle."

During the winter of 1954-55 preliminary study and planning was undertaken by an ad hoc committee set up by the U.S. National Committee for the I.G.Y.

This committee on March 10, 1955, recommended the inclusion of satellite vehicles in the U.S. effort for the International Geophysical Year of 1957-58, whereupon scientists from the National Academy and the National Science Foundation submitted the proposal to the Government. The President's public endorsement of the program on July 29, 1955, signaled its actual adoption. The worldwide reaction was immediate, enthusiastic, and warm in its praise for the leadership taken by the United States in this scientific satellite project.

Project Vanguard

In the meantime Project Vanguard was born in the Department of Defense with the Navy acting as project manager. Project director is Dr. John P. Hagen of the Naval Research Laboratory. The Navy would provide the rocket vehicles, radio and tracking equipment, the Air Force its launching facilities at Patrick Air Force Base, Florida, and the Army observation bases; all of these are necessary to make the satellite undertaking a success. The National Academy would concern itself with the decisions involved in planning the scientific, non-secret satellite vehicles and their orbits. To carry out these latter functions, Prof. Joseph Kaplan, Chairman of the U.S. National Committee for the I.G.Y., appointed a panel headed by Dr. Richard W. Porter, past president of the American Rocket Society.

Three-Stage Rocket

The problems are many. The satellite vehicle, even though it may weigh only little over 20 lbs., requires a great deal of rocket propulsion to achieve the necessary velocity, about 5 miles per second. To provide this propulsion efficiently it must be applied in stages: first a large rocket booster lifts the assembly above the bulk of the atmosphere and maneuvers it into the proper direction with a speed of some 5,500 ft./sec; secondly an intermediate stage which brings the final stage and satellite into the almost horizontal trajectory with a speed of 13,400 ft./sec, and finally a third stage which at an altitude of 300 miles adds the last required amount of speed to give the satellite the necessary orbital velocity of nearly 26,000 ft./sec (18,000 m.p.h.). The accuracy problems are severe. The velocity has to be kept within

about one percent of the designed value, and the angle from the horizontal must not exceed one to two degrees.

The overall contract for Project Vanguard has been awarded to The Glenn L. Martin Company of Baltimore, Maryland, the design of the first-stage rocket motor to the General Electric Company, the second stage to the Aerojet-General Corporation of Azusa, California. The third stage will be a solid-propellant rocket. Because of the possibility of failures in any of the stages and because of the severe accuracy requirements, ten or more launchings are planned in the hope that they will lead to several successful satellites which will remain above the atmosphere for many orbits.

The designed launching altitude is approximately 300 miles although launching errors in velocity and angle will make the orbit elliptical and therefore of varying altitude. Limits of 200 miles (perigee) and 1,400 miles (apogee) have been announced. At these altitudes the atmosphere, even though a better vacuum than we can ever achieve at sea level, still contains a large number of molecules with which the satellite will collide and which will rob it of some of its energy. After a few days therefore, depending on the details of the orbit, the satellite will spiral in, reenter the atmosphere, disintegrate and burn up before reaching sea level. In a perfect circular orbit at 300 miles it would "live" for about 100 days. Any large deviation from this orbit will shorten its life drastically.

Satellite Orbit

The details of the satellite itself are now being settled. The available rocket propulsion power limits the maximum weight of the satellite vehicle to something like 21½ lbs. Its dimensions will be small, of the order of 20 inches, in order to reduce the exposed area and therefore the atmospheric drag, but large enough to be trackable from the ground by optical and radio techniques. Under ideal viewing conditions at dawn and dusk, with the sky nearly dark, it will then shine by reflected sunlight and appear like a faint star which flashes across the sky in a few minutes.

The major problem revolves around the choice of orbit. Due consideration must be given to the available rocket propulsion power, the precision of the control system, the availability of a launching site and associated questions of range safety; even the cost and logistic problems of setting up a chain of worldwide tracking stations for observing and communicating with the satellite has to be considered.

The orbit now chosen for the initial satellites is inclined about 40° to the earth's equator. The satellite can then be seen from latitudes 40° north to 40° south (from New York to Buenos Aires in the western hemisphere, from Madrid, Naples, Ankara, Peiping down through all of Africa and Australia). In all likelihood, however, future satellites will not be confined to the 40° inclination. From the point of view of many scientific experiments, mainly geophysical, a higher inclination would be more desirable; a 90° inclination would of course produce a polar orbit which can traverse every part of the globe. The satellite, being outside the atmosphere, does not participate in the earth's rotation but its orbit stays fixed in space; during every orbit traversal it will therefore see a different portion of the earth's surface.

Scientific Space Laboratory

The question of what scientific equipment the satellite is to contain is being considered widely, and many scientific organizations have held special symposia to discuss just such problems, for example the Institute of Radio Engineers, the Institute of the Aeronautical Sciences, the American Meteorological Society, the Upper Atmosphere Rocket Research Panel, and others.

There is no lack of suggested experiments for the satellite. It seems that it can investigate many scientific phenomena in a very efficient manner. These include investigations of the earth's magnetism and mass distribution, of conditions in the lower and upper atmosphere, and range all the way out to the study of extra-terrestrial radiations, such as cosmic rays, interplanetary dust particles, and various radiations from the sun and stars. Even valuable checks of the Einstein theory of relativity can be performed by means of satellites.

Observatory in Space Revolutionizes Astronomy

It is perhaps not generally realized how restricted our earth-bound view of the universe really is. We see astronomical objects only in the visible part of the electro-magnetic spectrum. Thanks to developments in the science of radio we can now also observe the objects in our galaxy and beyond which emit radio waves. We have thus learned to extend the limited sensitivity of the human eye; the main obstacle now becomes our own atmosphere which absorbs most of the incident radiations and hides much of the universe from our view.

It is therefore not difficult to appreciate how even a small satellite will revolutionize observational astronomy and geophysics; much more so when larger and more elaborate satellites capable of carrying television cameras and telescopes become technically feasible.

We do not need to labor the great scientific importance of artificial satellites further; it is a foregone conclusion.

Dr. John P. Hagen, director of *Project Vanguard* at the Naval Research Laboratory, with a model of the three-stage rocket (scale 1 : 25) dismantled into its major components. The ball in the scientist's hand represents the actual satellite.

Will it Revolutionize our Lives?

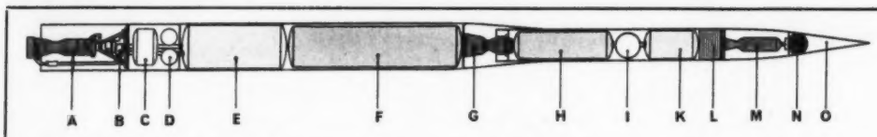
It is more interesting to speculate on the effects of this venture on our everyday lives. Now that man is taking his first, though indirect, steps into space, now that our scientists and engineers are getting ready to start a new science—the science of experimental celestial mechanics—will the beginning of the space age change our mode of life suddenly or drastically?

Predictions are always risky, but I don't think we should anticipate any violent changes. Unlike in the case of nuclear energy which hit us suddenly and forcefully, we have long been conditioned by science fiction, by countless magazine and newspaper accounts, and by TV to this coming age of space. No one will be particularly surprised when it officially begins.

It is reasonable to expect that most of us will remain earth-bound, that we will conduct our business and live our lives with both feet on *terra firma,* and that our main concern will still be, as it always has been—the weather.

Weather — A National Problem

This last remark is more than a figure of speech; living on the earth's surface we have a real earth-bound view and regard what goes on in the lowest layers of the atmosphere as most important. Indeed, the importance of weather can hardly be overestimated. Every section of our economy and of our national life depends on it; not only agriculture, but meat packers, canners, agricultural implement manufacturers, the building industry, etc. The vagaries of weather affect hydroelectric plants, city water supplies and resort operators. It is significant to watch the increasing extent to which airlines and other transportation com-



Cutaway drawing of the *Vanguard* rocket: (A) – General Electric X 405 rocket motor; (B) – propellant feed pumps; (C) – hydrogen peroxide tank; (D) – helium spheres; (E) – fuel tank; (F) – liquid oxygen tank; (G) – Aerojet-General Corp. rocket motor; (H) – nitric acid tank; (J) – helium sphere; (K) – dimethyl hydrazine tank; (L) – instrumentation compartment; (M) – solid-propellant rocket motor; (N) – satellite; (O) – nose cone.

The Vanguard Satellite Transport Rocket

Summary of a paper read by N. E. Felt, Jr., *Project Vanguard* engineer with The Glenn L. Martin Company, to the 7th International Astronautical Congress in Rome.

Shortly after President Eisenhower's announcement of the U. S. satellite programme on July 29th, 1955, The Glenn L. Martin Company, of Baltimore, Maryland, was selected by the Naval Research Laboratory as the prime contractor for the *Vanguard* transport vehicle for the planned American earth satellite. After extensive preliminary investigations, the company began about a year ago on the actual design of the *Vanguard*, which is to carry the satellite to the required altitude of roughly 300 miles and accelerate it to a departure speed of 25,900 ft./sec.

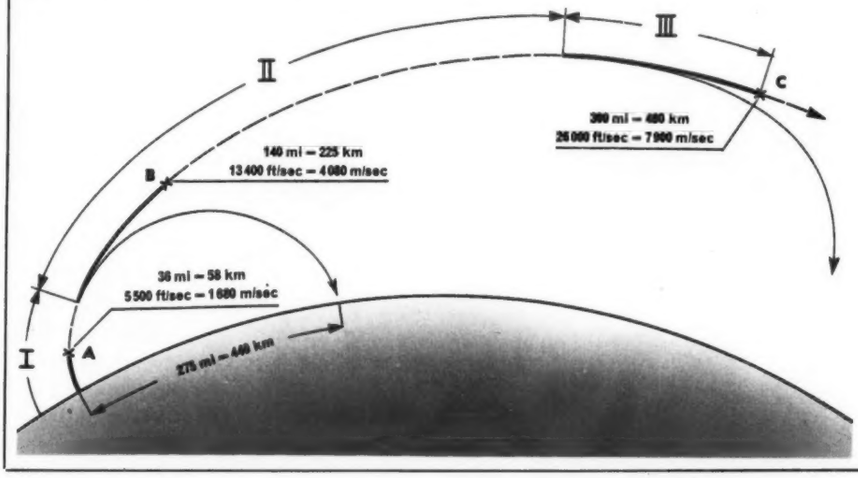
The rocket, which has no fins, is in three stages, each of which is of different diameter. The second and third stages fit partially into the preceding stage, so that the *Vanguard's* total length (approx. 72 ft.) is less than the sum of the three stage lengths.—The first stage is entirely of Martin design and is to be powered by a General Electric liquid-propellant rocket motor (A) with a thrust of more than 28,600 lbs. This motor, designated the X405, is gimbal-mounted and thus can be swivelled within certain limits. The thrust cylinder is moved by hydraulic actuators so that flight path control may be effected. Next to the rocket engine is the tank of hydrogen peroxide (C) which, after passing through a catalyst, decomposes into high-temperature steam to drive the turbine for the propellant feed pumps (B). The next compartment contains spheres (D) for the helium used to pressurize the fuel and liquid oxygen tanks. Forward of the helium spheres are the fuel tank (E) and the liquid oxygen tank (F). The fuel used is a gasoline mixture, consisting of 95% gasoline, 4% ethyl alcohol and 1% silicon oil. A conical skirt surrounds the rear end of the second stage. Length of first stage approx. 44 ft.; diameter 45 ins.

The second stage of the *Vanguard* vehicle contains a liquid-propellant rocket engine (G) built by Aerojet-General Corporation, of Azusa, Calif., and uses white fuming nitric acid as oxidizer and unsymmetrical dimethyl hydrazine as fuel. A gimbal mounting system and hydraulic actuation units similar to those employed in the first stage are used. Between the oxidizer tank (H; at the rear) and the fuel tank (K) is a sphere (J) containing the high pressure helium employed for pressurization. The helium drives the oxidizer and fuel under high pressure into the combustion chamber, thus avoiding the considerably heavier turbine pump system used in the first stage. —In a separate compartment (L) forward of the fuel tank are the required guidance, control, telemetering and instrumentation packages. The control system includes a three-axis gyro reference system supplied by the Minneapolis-Honeywell Regulator Company, Minneapolis, Minnesota, as well as the magnetic amplifier portion of the autopilot built by Vickers Inc., St. Louis, Mo. Diameter of the second stage is 32 ins., and length approx. 31 ft.

The third stage is a solid-propellant rocket for which a dual development programme is being conducted by both the Grand Central Rocket Company, Redlands, Calif., and Allegany Ballistics Laboratory, Cumberland, Maryland. The nose cone (O) of this stage carries the satellite sphere (N), which is released after jettisoning of the nose cone and burnout of the last stage. The whole third stage, including the 21.5-lb. satellite, is spun rapidly about its longitudinal axis while still attached to the second stage; the spin thus imparted is designed to stabilize the trajectory of the last (unguided) stage. For this purpose the propulsion unit is mounted on a turntable in the nose of the second stage. Turntable and third stage are rotated by small tangential rocket units.

The *Vanguard's* trajectory is illustrated in the drawing below and is discussed in greater detail in the article by Dr. S. F. Singer.

The *Vanguard's* trajectory. The burnout points of the three stages (I, II, III) are marked A, B and C; altitudes and trajectory speeds at burnout are also entered.



panies, and even insurance companies, are employing meteorologists. There has been a tremendous rise in the business of weather consultants, firms which will forecast specific weather problems for a client who may produce umbrellas and rainwear, sports equipment, fans or heaters. The list is endless; weather touches all of us earthlings.

Floods, hurricane damage, droughts, all these may be regional in extent but they have become of immense national concern. More and more therefore we must focus our attention on the problem of weather prediction, not only on a day-to-day (synoptic) basis but well in advance on a longer period basis: wet spells, heat waves, droughts, frost in every-day language; the irregular motion of air masses, the formation of weather fronts and cyclonic systems, of "highs" and "lows," in the language of the meteorologist. The problem is to predict when and how these disturbances are formed and superimposed on the vast globe-girdling circulation of the atmosphere. The behaviour of the atmosphere follows known physical laws and can in principle be described mathematically; in practice this description is exceedingly complicated. Nevertheless, remarkable success can be achieved in predicting the weather by numerical techniques using modern high-speed electronic computers. The main stumbling block is the lack of sufficient world-wide meteorological data based on observations.

It turns out, and indeed this is perhaps the main point of this article, that an artificial satellite carrying proper instruments, even though above the atmosphere, is in a surprisingly good position to tell us what is going on in the lower atmosphere. The main reason for this is that the satellite can view the earth whereas we cannot: it is too difficult and too expensive. In fact less than 5% of the earth's surface is under meteorological surveillance, with a heavy concentration of stations in Europe and in the U.S.A. and wide gaps elsewhere. During the International Geophysical Year, meteorologists will try to fill some of the largest gaps, particularly in the Antarctic, but they cannot approach the continuous, hour-to-hour coverage of a satellite.

Solar Radiation is Source of Weather

The circulation of the atmosphere is caused by the unequal distribution of energy from the sun; more energy arrives at the equator than at the pole. The main job of the satellite is to measure the energy retained by the earth. This is an easy measurement: a simple photocell pointed downward can determine the fraction

This picture constructed by Dr. Harry Wexler, of the U.S. Weather Bureau, shows typical cloud formations over the North American continent as seen from a 4,000 mile high meteorological satellite. A cyclonic system over Hudson Bay extends southwards towards Texas; another cyclone can be seen in the Gulf of Alaska. – Also, a hurricane developing in the West Indies, low stratus and fog off the lower Californian coast, over the Great Lakes and Newfoundland, and cloud streets in the trade wind region.

of sunlight reflected back into space (mainly by clouds); the rest of the energy remains with the earth and the atmosphere and provides the driving force for the large-scale motions of the atmosphere.

Storm Tracking

A simple satellite as a tool of meteorology can do even better. By reporting on cloud patterns it allows us to recognize typical weather conditions, and track the development and motions of cyclonic storms, hurricanes, etc. Such a satellite may become a reality before the end of this decade. Soon thereafter with further developments in rocket propulsion, it should become possible to launch the "ideal" meteorological satellite suggested by *Dr. Harry Wexler* of the U.S. Weather Bureau, which carries a television camera and traverses the earth in a 4000 mile high pole-to-pole orbit. (As in the case of the small satellites the information would be stored and relayed to ground receiving stations by radio transmissions.)

Control of Weather?

It seems that the beginning of the "space age" will not immediately call forth interplanetary travel, but rather an increase in man's understanding of the physical environment of his own planet, Earth. But man's ingenuity knows few bounds. Perhaps, as in the case of the atom, increased understanding and knowledge of the atmosphere will prove to be only the forerunners of man's control over his natural environment.

Space travel

Instrumental Satellites and Instrumental Comets

By Krafft A. Ebricke, Chief, Preliminary Design Systems Analysis, Convair, San Diego, California

Rocket-powered vehicles find only limited peace time application on the earth's surface. Their field is the upper atmosphere and space. The instrumental satellite in the earth-moon space and its more powerful successor, the instrumental comet, capable of entering interplanetary space, can be developed into a new tool of astronomical and space research. Furthermore, the scientific and engineering know-how gained in this manner is bound to hasten the development of manned space flight. Great as the technical and scientific significance of the first generation of man-made satellites will be, they have severe limitations in terms of payload capacity and altitude. Future progress is directed toward satellite recovery, orbits of higher energy and payloads of greater weight and complexity.

Flight Performance

Two factors are particularly responsible for the early feasibility of extended space research based on automatic vehicles. First, the payload weights involved are small compared to the weight requirements and accompanying logistic problems which characterize even a modest manned space operation. Therefore, no excessive demands need to be made on size and number of rocket boosters. Secondly, recovery is not required. For instrumental comets this means that the energy requirement for a given interplanetary mission is cut in half, or even less if the probe passes the target planet along a hyperbolic orbit rather than becoming its satellite.

An intercontinental ballistic missile (ICBM) covering a quarter of the earth's circumference, if launched from a satellite orbit some 300 nautical miles (540 km) above the earth, is capable of roaming the solar system between the planet Pluto and about one-third the distance of Mercury from the Sun. The vehicle could also land a payload on the moon or could become a satellite of Venus or Mars. For a hyperbolic passage of Mercury, Venus or Mars, less performance would be required than for an intermediate range ballistic missile (IRBM) of, say, 1,500 n.mi. range. From the viewpoint of scientific exploration of a large part of our solar system, the long range ballistic missiles have, therefore, a unique and intriguing potential.

Our diagram surveys the ideal velocity requirements for elliptic flight paths within the solar system between a perihelion distance of about 5,000,000 n.mi. and an aphelion distance as far out as Pluto, (about 3.3×10^9 n.mi.). By comparison, the ideal velocity, including gravitational and drag losses, of an ICBM is approximately 28,000 ft./sec (8.5. km/sec). The above-mentioned interorbital performance capability of an ICBM can, of course, not be fully utilized, because the vehicle must first be delivered into the satellite orbit. However, considering the great many missions of scientific interest in the inner solar system alone, and the effect on the payload weight of utmost miniaturization of instrumentation and communication equipment, the instrumental comet for space research outside the earth-moon system becomes a distinct possibility, at least from the performance standpoint.

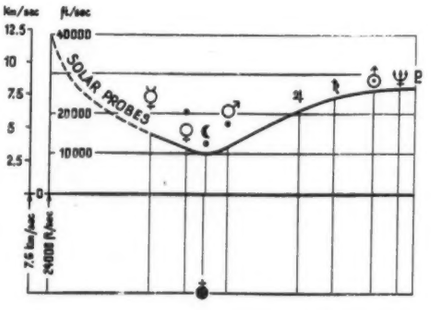
Flight Accuracy

Flight accuracy is another important consideration for cislunar satellites, which move in orbits inside the lunar orbit, for lunar satellites, as well as for instrumental comets. The change of the orbital elements due to a given small velocity error at cut-off increases rapidly with the apogee distance of the desired ellipse and finally grows beyond all limits as parabolic flight conditions are approached. Assuming an elliptic orbit of 60 earth radii apogee distance, an error of 1 ft./sec out of 24,890 ft./sec departure velocity from a 300 n.mi. orbit causes a displacement of the apogee by 514 n.mi. (930 km). Therefore, flight accuracy is particularly important for transfer orbits to the moon.

It may become necessary or desirable to introduce human control of the vehicles' attitude and flight path by being able to override the space-borne guidance and control system and to determine the duration and direction of thrust in vehicles equipped with a small propulsion system. This art of terrestrial monitoring can eventually be developed to the lunar surface. By this technique, cut-off accuracy requirements could be relaxed considerably and corrections made after sufficient time has passed to allow for the cumulative effect of small errors which may have been below the practical threshold of the guidance system at the moment of cut-off. The practical application of terrestrial control over the motion of space vehicles depends, of course, entirely on the accuracy of tracking within the range under consideration.

In the case of a flight to Mars, a 1 ft./sec error in departure velocity results in a displacement of the aphelion point of the transfer ellipse by about 6,400 n.mi., while in the case of a flight to Venus, the same error results in a displacement of the perihelion point by approximately 2,000 n.mi. These displacements do not take into account the gravitational attraction of the target body. For the moon, this results in an increase in permissible error to at least some 75 ft./sec.

Diagram of the ideal burnout velocities for instrumental comets and satellites launched from a 300 nautical mile high earth satellite orbit for a hyperbolic passage of the planets in our solar system. The unbroken line shows the velocity requirement for such hyperbolic passage. If the comet is to orbit the planet as a satellite, however, the higher energy required is indicated by black dot. The thin horizontal line shows the (inherited) circular velocity of the earth satellite (24,900 ft./sec = 7.6 km/sec).



Astronautical and Space-Medical Research

Among the many technical and scientific areas of astronautical research with automatic space vehicles mention can be made of the following: *Propulsion systems* (low thrust thermal or electrical systems), *electronics* (data transmission, guidance systems, tracking), *equipment* development, *satellite* engineering and operation, *aerophysics* (free-molecule flow physics, re-entry aerodynamics, aero-thermodynamics), *geophysics* (outer atmosphere research, geomagnetic

field, geo-electric phenomena, earth albedo, geodesy, meteorology), *cosmophysics* (radiation, distribution of cosmic matter, magnetic fields, lunar reconnaissance etc.).

Space medicine is the other basic problem area which is involved in manned space flight. The automatic satellite provides a true "sealed chamber" under correct space conditions. It represents the only means of studying complete weightlessness for practically any length of time. For reasons of brevity, the space medical satellite test chamber shall be designated as biosatellite. A biosatellite does not necessarily house living beings, but can serve the testing of quality, functionality and reliability of biotechnical equipment under accurate environmental conditions in space as well as during re-entry into the atmosphere. One can hope eventually to tackle the problem of the total biosatellite in which the biological loop is closed and perfect symbiotic equilibrium of plant and animal life is achieved. Such a video-equipped total biosatellite comes close to the ultimate tool for the biologist and space medical researchers.

The first satellites will not employ reaction forces in any form after delivery in their respective orbits. However, more advanced satellites will be provided with impulse producing equipment; first for jet attitude control, later also for propulsion.

A path correction, such as shown in the first figure, following a lunar passage, becomes necessary for re-adjustment of the vehicle's path after perturbation by the moon, if the vehicle is to be guided back to the immediate vicinity of the earth. Finally, lunar probes, becoming either circumlunar satellites or lunar landing vehicles, must possess propulsion systems for transfer into circumlunar orbits or for braking their speed during the descent to the moon's surface. Except for lunar landing, where the minimum thrust is dictated by the lunar weight of the vehicle, the thrust should be as low as general systems considerations permit. This not only increases the maneuvering accuracy, but in the case of terrestrial control is more advantageous at greater distances when the time lag between emission and reception of signals has to be taken into account. At lunar distance this time lag, about 1.3 seconds, becomes important. This is even more the case with instrumental comets where the transmission time is of the order of minutes.

Equipment development and reliability are of fundamental importance for space technology in general. We owe our present high technological standard on earth to omnipresence of a well developed maintenance and repair system which reduces reliability requirements of individual components, especially time-wise. This advantage is not available in space. Long range manned space flight faces a difficult hurdle in the "reliability barrier." Automatic space vehicles can contribute greatly to overcoming this difficulty.

Circumnavigation of the moon: the unbroken line indicates the satellite's actual flight path, after allowance for lunar perturbation, while the broken line shows the flight ellipse without lunar perturbation (with an apogee of 70 earth radii). The numbers give hours after departure from the earth satellite orbit and refer to six positions of the moon and the satellite (connected by a straight line of vision). During the return flight the rocket motor is ignited again for a short period in order to correct the flight path to compensate for perturbation. The vehicle returns to a different orbit than its orbit of departure.

Cislunar and Lunar Probes

Of scientific interest in a cislunar research program are the distribution of cosmic matter in the earth-moon plane and at angles to it, the motion of discharged solar material in the earth-moon field (which also involves a study of the magnetic field between earth and moon), cosmic radiation and measurement of the earth's albedo from greater distance. The orbits of satellites of the moon can be expected to be elliptic for reasons of practical limitations of guidance accuracy and because of terrestrial perturbation.

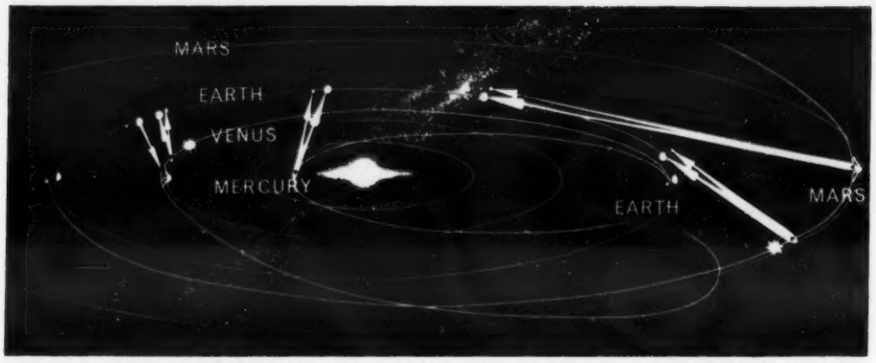
The desirable distance from the moon will depend on the mission of the lunar satellite. For instance, one application would be to gain more definite information about the true shape of the moon. One could attempt to measure the perturbations of the circumlunar orbit through which the deviation of the moon's shape from a true sphere would reveal itself. It appears that these deviations are small, much smaller than the corresponding deviations of the earth's shape. Therefore, the lunar perturbation will be small also. In order to obtain a measurable effect and eliminate as much as possible the interference from terrestrial perturbation, very close proximity to the moon is required. Fortunately, there is no atmosphere to speak of which could interfere with such a close-by orbit. However, the smallness of the perturbations will make very accurate observations mandatory. Inflated tracer bodies could be used for such observations. For instance, an inflated balloon-type tracer body of about 40 ft. diameter would appear as a star of approximately 11th magnitude.

Another point of scientific interest is the search for a lunar magnetic field and the irradiation of the vehicle by cosmic particles in the immediate vicinity of the moon. The satellite can also search for manifestations of a lunar residual atmosphere, such as optical or electrical phenomena which require great nearness to be discovered. Provided sufficient guidance accuracy is available, a satellite can be used to release very large and light "balloons" while passing very close by the lunar surface. The motion of these balloons can be studied for signs of atmospheric effects.

One of the most intriguing applications of the lunar or appropriately launched cislunar satellites is, of course, the exploration of the lunar surface proper. This can be done in several ways; by optical observation, by radiation ferreting to investigate the possibility of radiation sources on the moon's surface, possibly as a result of the effect of cosmic radiation on mineral deposits; by producing a gas blast artificial "wind" near the surface to determine the consistency of the lunar soil, by exploding bombs on the surface and finally, by controlled landing and re-ascent of lunar satellites.

Instrumental Comets

Instrumental comets will be employed in one-way missions, at least in the foreseeable future. Therefore, no propellant weight has to be carried for the return flight. Liquid oxygen or fluorine and possibly hydrogen can be used for departure without requiring provision for storage of these materials over a period of months or years. As the probe escapes the earth's field along a hyperbolic path, the main propulsion system, including the tanks, can be separated from the comet. If provisions for later path corrections—by terrestrial command or otherwise—are desired, a second small propulsion system operating on less volatile propellants of good long-time storage characteristics can be used. The thrust-to-weight



Exploration of inner solar system by instrumental comets: shown here are the sun and the orbits of Mercury, Venus, earth and Mars. On the right side a solar probe (intra-mercurial perihelion) and a Venus probe (which experiences marked perturbation from Venus) are seen starting out. Departure of a Mars probe is shown on the left. The Venus and Mars probes detonate a nuclear bomb shortly before reaching the target planet, whereupon tracking takes place using earth, moon (and transponder satellite). The planets could be explored by radar or by television cameras (far right in picture).

ratios involved in these maneuvers will be small and the required changes in flight path will be slight, so that supreme impulse propellants are not required. Absence of food, water, air conditioning and many other biological and safety requirements constitute an enormous weight saving for the instrumental comet, as compared with the interplanetary space ship.

The second figure depicts three interesting missions for instrumental comets within the inner solar system: Exploration of the sun (solar probe), of Venus and of Mars. This, of course, does not exhaust the possibilities of operation in the inner solar system.

The *solar probe* is perhaps the most intriguing application of instrumental comets, at least for the physicist and astrophysicist. It is also an example of the capability of the instrumental comet of entering regions of space into which manned ships will not be able to follow for a long time to come, if ever. The solar probe is shown in the figure to approach the sun as close as about 16,000,000 n.mi., that is, twice as close as Mercury. The diagram shows that this orbit is quite expensive in energy. The radiation equilibrium temperature of the probe at this distance is 700 to 800 °K (800 to 1,000 °F) or less if provisions are made to increase the effective emission-to-absorption ratio above 3. This path, therefore, is an extreme example of the motion of solar probes with perihelion distances inside or outside the Mercury orbit.

The scientific significance of the solar probe cannot be discussed here even in approximate detail. A few of the problems are: the nature of the solar corona (ionization and excitation of coronal atoms); extension of coronal material into space; support and heating of coronal material; electron density in inner and outer corona; electric and magnetic fields in solar space; evaporation of protons and electrons from the corona and solar corpuscular radiation in general; solar cosmic radiation. The last point is of considerable astrophysical significance. In general, instrumental comets offer a possibility of distinguishing more clearly between solar and extra-solar cosmic radiation. Better knowledge of the sun's cosmic radiation is required in order to solve the problem of whether extra-solar radiation is of stellar or interstellar origin. Another intriguing mission of the solar probe is the exploration of the zodiacal light, a nebulous light observed to precede or follow the sun shortly before sunrise or after sunset. This light is caused by a huge disc-shaped dust cloud which lies in the ecliptic plane. Its density at the earth's distance is extremely low, but increases with decreasing distance from the sun, particularly inside the Mercury orbit, as indicated by the increasing light intensity. Very little is known about composition, mass (or density) and motion of this cloud.

Planetary probes require comparatively less energy than some solar probes, but have longer transfer times. The atmospheres of Venus and Mars are still incompletely known. Close passages could reveal important new information on atmospheric composition and, for Mars, also on surface features. If one stays within the earth-moon system, one can never get closer to Mars than about 35 million miles. Employing the greatest magnification available to the large telescopes on earth, Mars still appears only as large as the moon appears to the naked eye. This corresponds roughly to looking at Mars from 450,000 miles distance without a telescope. Venus comes closer, about 25 million miles, but then it stands between earth and sun and cannot be observed. The "full Venus" is over 200 million miles away. Under these conditions even a rather inaccurate hyperbolic passage of an instrumental comet, equipped with a wide-angle telescope of modest magnifying power, some 30,000 to 50,000 miles from the planet's surface, is bound to show a wealth of new details of the Martian surface and the structure of the atmosphere of Venus. Another interesting possibility is to probe more deeply into the Venus atmosphere by means of radar, measuring the attenuation spectrum of various radar frequencies from uncondensed as well as condensed gases, without having to approach the planet too closely.

Radar mapping Venus would for the first time yield information in regard to its surface features. However, for this purpose the comet must approach Venus quite closely, within about 60 to 100 miles of the planet's surface. Our figure shows a marked perturbation of the comet's path by its close passage of Venus. This perturbation can be used for determining more accurately the mass of Venus, presently not very accurately known due to the absence of a natural satellite.

Tracking and Data Transmission

The gathering of information by cislunar and lunar satellites or instrumental comets is useless if it cannot be transmitted to the earth. To this purpose one must be able to locate the vehicle in the depth of space, an infinitesimal speck among myriads of stars, and receive its message. Tracking and data transmission are the two parts of the communication link with the vehicle. Together with the gathering and possibly recording of data they represent the operational capability of the space vehicle.

For data transmission, it would be advantageous to have a relay station in space (satellite or on the moon). In space, there is no atmospheric attenuation which restricts transmission frequencies from the surface to some 10,000 mcps, and the power requirement decreases with the square of the transmission frequency. By using space-borne transponders, the comet's signals would be caught and re-transmitted at a different (i. e. lower) frequency to earth.

Tracking problems increase with the range of the space probe. Instrumental comets can first be tracked by flashing lights while they recede from the earth along the outward-bound branch of the escape hyperbola. During this time, path corrections may already be made, computed on the ground, transmitted to the vehicle and executed by the low-thrust engines. By the time the flashing lights fade away among the stars, the path will be determined well enough to know where to expect the first flash after a lengthy "dark period." This flash can be made sufficiently powerful by using a nuclear source (i. e., a small nuclear bomb) released from the comet prior to explosion. Such flashes are indicated in the second figure for the Mars-bound and Venus-bound instrumental comets. The flashes will enable optical acquisition (straight dashed lines to the earth in the figure) and subsequent electronic lock-on. Thereafter, the planetary or solar reconnaissance mission can begin. Indicated in the figure are a TV report from the Mars probe and a radar report from the solar probe.

This quite cursory survey already shows to what heights space techniques and space operations may be developed without the need for man to leave the earth.

Still, it is not difficult to show that instrumental satellites and comets cannot replace manned space flight in the long run. However, they do permit far-flung space research sooner, thereby serving science, expediting the development of manned space flight and increasing its chances of success.

THE CORD HAS BEEN CUT

Man has at last severed the tie that bound him to Mother Earth. *Gyroscopic stable platforms* and *inertial navigation systems* can now free him from all terrestrial sources of information . . . In the outer regions, where the terms Up, Down, East and West are meaningless, these fantastically accurate instruments compute position, course, and attitude entirely without reference to maps based upon the earth's surface . . . Lear has *pioneered* the design and production of inertial stabilization and navigation systems. Today these devices guide and stabilize man's most advanced missiles and aircraft. Tomorrow they will orient and control spacecraft yet to be developed.

LEAR

masters of master reference systems for all aircraft

LEAR INC., SANTA MONICA, CALIFORNIA IP-10

TURN AROUND

In the all-new, propjet Electra, Lockheed design, skill and imagination have produced an airliner with ground handling at a minimum – 12 minutes for en route stop servicing, and complete turnaround in as little as 20 minutes! This represents a big saving in time, in labour, in money – a saving made possible by proper spacing of servicing and replenishing points: all servicing operations can be carried out simultaneously – without interference with each other or passenger loading. In addition, the Electra embodies many other outstanding features: range flexibility – between 100 and 3,000 miles from large and small airports: faster cruising speeds: lower fuel costs – all of which open the way to faster flight schedules, smaller fleet requirements and increased profits.

128 ELECTRAS have been ordered by American Airlines - Braniff International Airways - Eastern Air Lines - KLM Royal Dutch Airlines - National Airlines - Western Air Lines

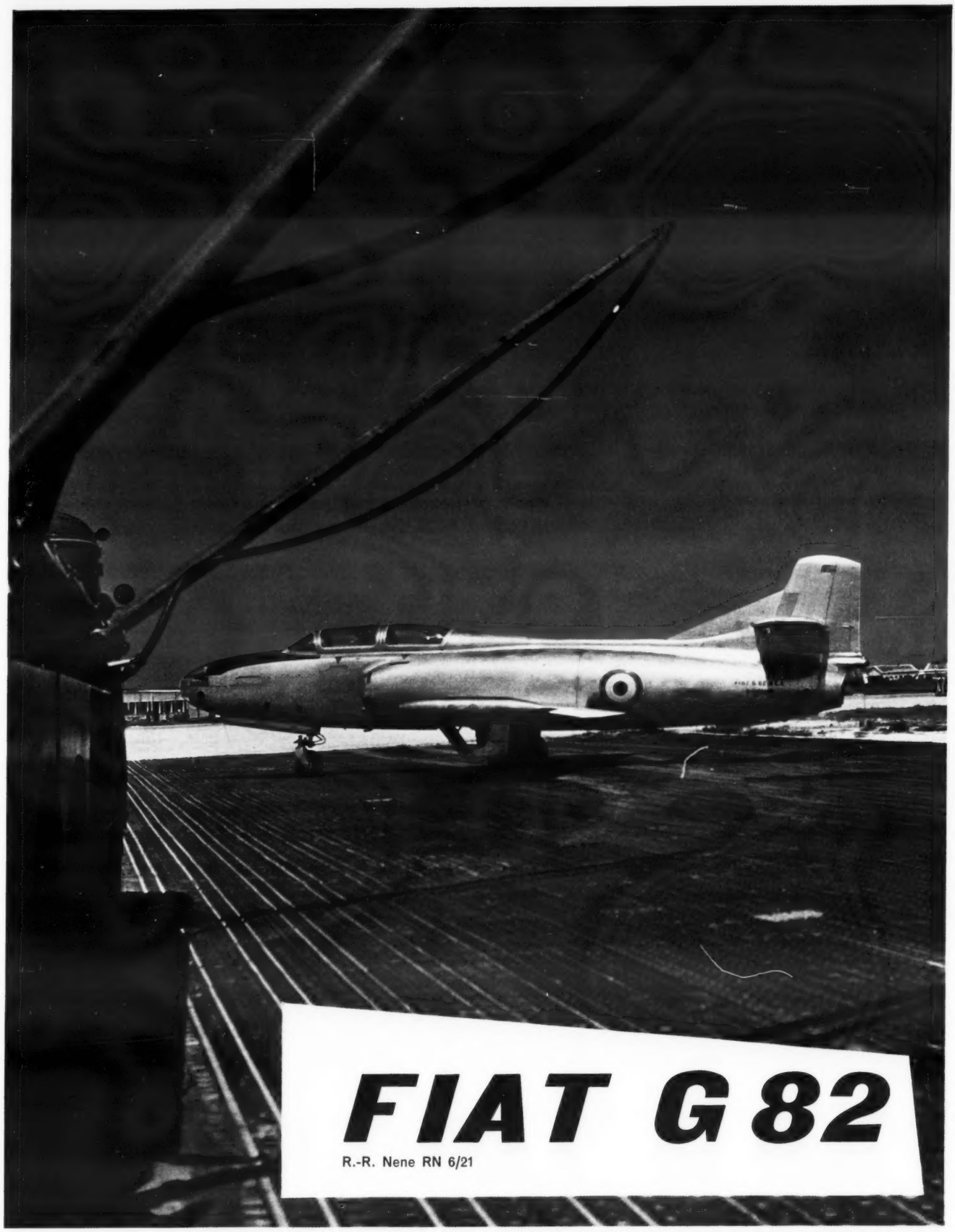
LOCKHEED AIRCRAFT CORPORATION · CALIFORNIA DIVISION · BURBANK · CALIFORNIA · U.S.A.

with the versatile

Lockheed

IN 20 MINUTES

Electra



The jet trainer which obtained the most votes from the pilots of the N.A.T.O. evaluation teams. Fast, manoeuvrable, safe. No limitations on the execution of spiral turns.

Satellites as Weapons

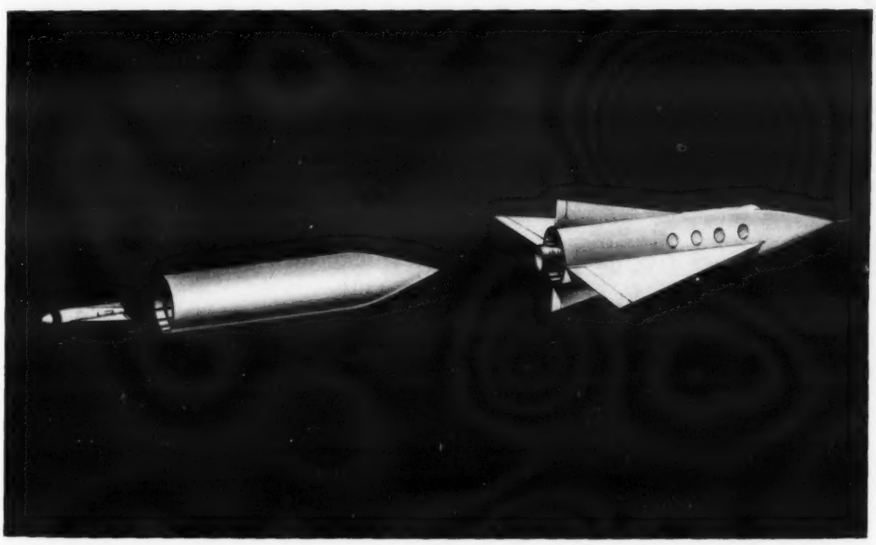
However peaceful may be the first dwarf satellites that circle the earth, to investigate the composition of the upper atmosphere, to study the weather and to measure cosmic radiation, for example, it is unlikely that a manned satellite would be limited to such civilian tasks. In this connection the remarks made by Dr. Wernher von Braun, development operations chief of the U. S. Army Ballistic Missile Agency, to the Association of the U. S. Army at Washington's Sheraton-Park Hotel on October 26th, 1956, deserve attention.

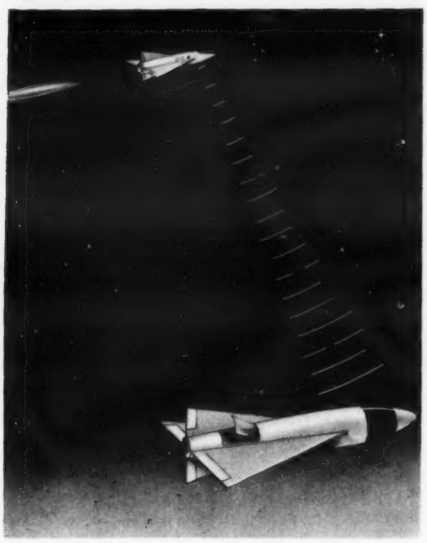
The manned satellite vehicle, said Dr. von Braun, would be eminently suited to serve as a key element in a guided weapons system, with which practically any point on the earth could be attacked. The principle of this weapons system is illustrated in the accompanying drawing: the orbit of the manned satellite, an electronic missile guidance centre, is represented by the outer circle, the satellite itself by a delta aircraft. When the satellite is in a favourable position, a multi-stage cargo rocket would be sent up to it from the ground station (ascent path at nine o'clock position), whose burnt-out final stage would follow the satellite ... as a well-trained dog follows his master. To reach its target on the earth—which would meanwhile have rotated further underneath the satellite orbit—the missile would be launched some 270 degrees of longitude (16,200 nautical miles) before the target. It leaves the transport rocket behind, makes half a loop and then approaches the earth's surface in a glide (inner curve), under continuous guidance from the satellites. The impact at the target is marked as an A-bomb mushroom.

The complete satellite weapons system *(top)*.

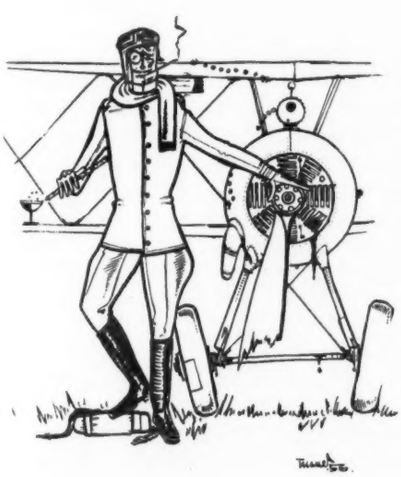
Below, left: The guided missile (left) has left the ferry rocket rearwards and is preparing for its half loop. The manned satellite vehicle (right) orbits with rocket power plant extinguished.

The missile nears its target on earth in a controlled glide. It remains under the satellite's control right up to impact.





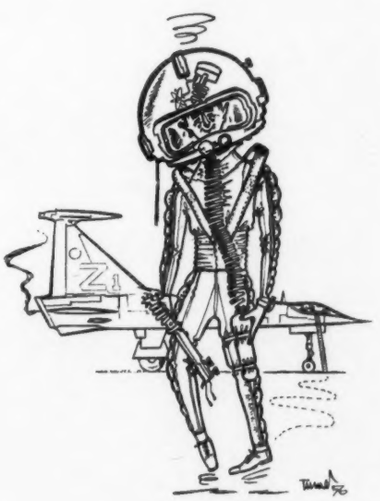
A Pilot's Lament



...I always loved to fly. Not very many years ago I would climb into a contraption made of fabric and string and take off into a breeze of fresh country air, fly around on the bumps, look for an occasional *Spad* or a *Taube* and maybe shoot a couple of rounds of Webley .38 at him. I still rejoice at the bumps and creaks of a landing, the howl of the motor and the sweet smell of aviation fuel at the airfield.

But ...

...in the cockpit today I don't feel the air any more. All I can smell is a damned rubber mask or a plastic helmet, and now I am told that I am not really needed anymore, that they have a new black box... And on top of that they have even invented an interceptor you don't have to fight because it shoots itself down with its own guns (or so the U. S. Navy says...). What has happened to the airman's world?



Aircraft comfort in 1959 . . . cabin of a Boeing 707-120 *Stratoliner*.

Aircraft comfort in 1934 . . . cabin of a Fokker F-20 three-engined airliner.

Aircraft Comfort in 1959

Boeing 707-120 *Stratoliner* four-jet commercial transport.

Visitors to the Los Angeles area can admire two full-scale mockups of new commercial transport aircraft: in Santa Monica the one of the Douglas DC-8[1] and in Burbank that of the Lockheed L-188 *Electra*[2]. Both models show the size of the new aircraft under construction, as well as certain details of their structure, and thus convey an accurate idea of the four-engined giants—jet or turboprop—being prepared by Douglas and Lockheed.

The third, much-discussed design, the four-jet *Boeing 707,* has now been flying as a tanker-transport for nearly two years, so that its makers have had no need to build a new mockup. Instead Boeing has undertaken a different project.

On the southern tip of Manhattan, near the docks, stand huge warehouses. Driven down to this neighbourhood, you land in 28th Street, in front of one of these warehouses. You are then taken by cargo elevator to one of the upper storeys, in not altogether attractive surroundings. But suddenly you find yourself in a large reception room, where several gentlemen, including a very polite uniformed security official, welcome you. You write your name in the guest book and await events.

As though at a magic word, a folding door opens, and two American air hostesses—you know how charming they are—invite you to climb into an aircraft cabin—a cabin such as you have never seen before!

You are invited to take a seat, fasten your seat belt and go along on the "flight". The

[1] cf. Interavia No. 11, 1956, p. 895.
[2] Description and pictures shortly.

engines are "started up," but their recorded noise is not disturbing, and from the loudspeaker comes the voice of the aircraft's captain: "Welcome on board." The invisible captain introduces you to his aircraft.

You begin to wonder if you are dreaming. Such comfort in an aircraft, a completely new atmosphere, a colour symphony in muted tones.

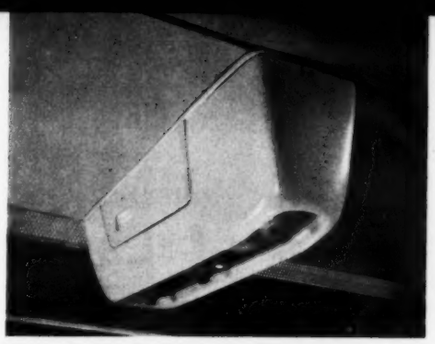
Soft light above each row of seats, bright light from the cabin ceiling. When the lighting is dimmed, the ceiling lamps look like the firmament, and you sleep under a "starry vault." Instead of the fixed metal footrests you are used to, you find movable pads. The public address loudspeaker has disappeared, and the captain speaks to the passengers individually. Above each row of seats is a box conveniently grouping loudspeaker, reading lamps (an improved design), bells to summon the cabin crew, a container with an oxygen mask for each passenger, in case something should happen to the pressurization system at altitude.

As for the windows, there have never been so many in any cabin, and each one of respectable dimensions. Fabric curtains are a thing of the past: pull down a smoke-tinted blind and you shut out the outside glare (important at high altitudes); pull up another plastic blind, and the window is blacked out completely.

Galleys, toilets and coat racks are all little masterpieces of decoration. Service aboard such an aircraft must be a real pleasure to the crew.

Chairs are roomy and more than comfortable. The seating arrangement can of course be modified, within a few minutes it is claimed. The cabin shown you here has 98 first class seats plus two club lounges for six passengers each with comfortable leather armchairs, one each fore and aft of the cabin. Two galleys, four toilets, two entrances also fore and aft. With a cabin length of 94 ft. 8 ins. this seems essential. The first-class layout of the Boeing 707-120 *Stratoliner* can carry 125 passengers, its tourist version up to 146. Don't worry, you'll have plenty of room.

The Boeing 707's interior is the product of joint efforts by Boeing and the New York industrial design firm of Walter Dorwin Teague Associates. The mockup took six months to build and cost more than $500,000. A good capital investment. The customer can see what he's getting for his money and can discuss special requirements as regards colour schemes and other details. And even before he puts his 707s into service he can advertise in words and pictures a comfort such as passengers have not yet dreamed of. For the first time there is a serious rival to the luxury ocean liner.



The service unit above each row of seats contains loudspeaker, reading lamps, "fasten seat belts" notice, bell for cabin service, oxygen masks and pipes.

A folding table in front of each seat.

"Welcome on board!" There is a door both fore and aft.

Windows can be shielded from glaring outside light by pulling down a smoke-tinted plastic shade (fourth window from right) or blacked out entirely by pulling up an opaque blind (second window from right).

Two galleys, one fore and one aft.

"... To 1959's passenger comfort!" The *Stratoliner's* first-class cabin (98 passengers) has two club lounges with leather armchairs for six passengers.

Space travel

An Airborne Method of Launching Satellites

by Dr. Aurelio C. Robotti, Turin

It is well known that, in order to reach the great heights (and speeds) needed to place an artificial satellite in its orbit, multi-stage rockets are required. If, instead of being launched from roughly sea level, these rockets could start from the top of the world's highest mountains, the same ultimate height could be reached with a much better ratio beween payload and gross weight. Pursuing this idea still further, it has been suggested that large rockets should be launched from altitudes about twice as high as the highest mountains by using balloons or aircraft as "lifts" to carry them up to launching height. Though simple in itself, the idea has hitherto met with insuperable obstacles when it has been a question of applying it to the large rockets under consideration for astronautical undertakings. The following article therefore proposes a practical solution to this problem.

*

In order to make my proposals as concrete as possible, I have based them not on projects but on existing vehicles whose characteristics are known:

— the *Bumper* two-stage rocket as satellite carrier;
— the *Convair F-102A* all-weather fighter as mother aircraft for the satellite carrier[1].

As is known, the *Bumper* was launched at White Sands Proving Ground, New Mexico, in 1950, at an angle of 80° to the horizontal. When the first stage (consisting of a V2 rocket) burned out at an altitude of approx. 32 km, the second stage (a *WAC Corporal 5*) came into operation, reaching a max. speed of 2,235 m/sec (or 2,300 m/sec according to other reports) and a max. altitude of 390 km (or 403 km). Personally I consider the more modest results to be more likely and have therefore used these in constructing my trajectories.

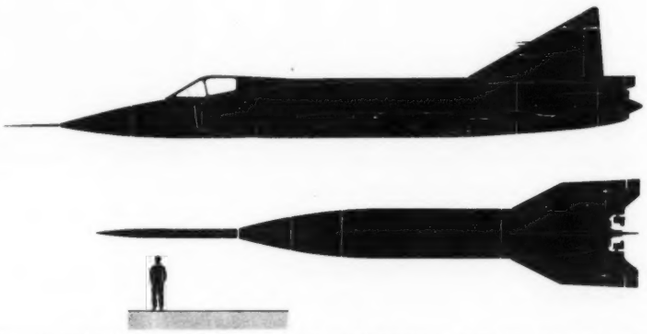
I have calculated what would have been the performance of the two-stage *Bumper* if, instead of starting off from the ground with an initial velocity of zero, it had been launched from a height of 14 km with an initial velocity of 150 m/sec. The result is an increase in the first stage's burn-out speed to 1,856 m/sec (instead of 1,225 m/sec) and in corresponding altitude to 59.6 km (instead of 32 km). The second stage max. velocity becomes 2,740 m/sec (instead of 2,235 m/sec), its altitude at burn-out 158.5 km (instead of 91 km) and its max. altitude 587 km (instead of 390 km). The latter figure is roughly 50% greater than the value obtained at White Sands.

If the *Bumper* were raised to 14,000 m and given a velocity of 150 m/sec at this altitude by the conventional method of using a booster, the latter would have to develop a total impulse of 1,320 secton and would have a total weight of approx. 10,000 kg. In other words, the *Bumper* would be transformed into a three-stage vehicle, with its first stage weighing 10 tons.

*

If we examine the diagram of the Convair F-102A and the 12-ton *Bumper* rocket, we realize immediately not only that the aircraft would not take off with an extra load of 12 tons, but also that it is practically impossible to find a reasonable way of attaching the two structures. Even if these two obstacles were overcome, and the aircraft succeeded in climbing to 14,000 m with its great overload under its belly, it would be impossible to launch the *Bumper*. Obviously the aircraft could not place itself in a vertical attitude, and horizontal launching would be useless because of the rocket's low initial accelerations.

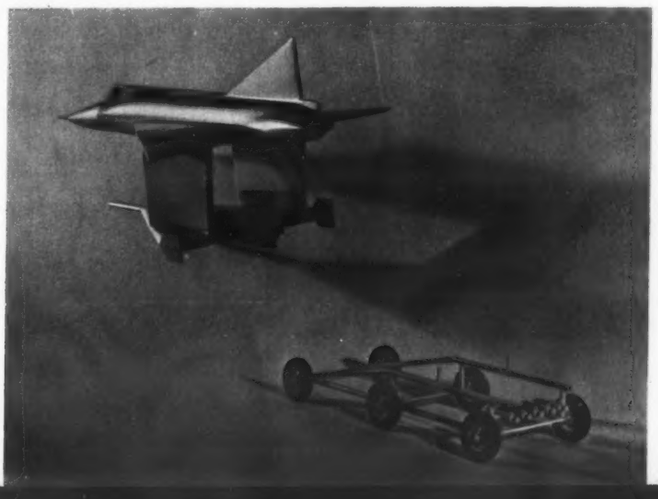
My proposal, therefore, is to give the missile a lifting structure, in the form of a delta wing with a span of approx. 9 m. For the same total weight of 12,245 kg, this configuration would have a wing loading of



Comparative size of the Convair F-102A all-weather fighter and the two-stage *Bumper* rocket.

[1] I should like to express my thanks here to the Convair Division of General Dynamics for providing technical material.

Model of the "Robotti composite biplane," consisting of a Convair F-102A and a two-stage rocket with delta wing. Right, the take-off trolley with JATO rockets.



The mother aircraft of the combination, the Convair F-102A supersonic all-weather fighter, with delta wing and "coke-bottle" fuselage: max. speed at 36,000 ft. altitude approx. 930 m.p.h., ceiling 59,000 ft.

approx. 300 kg/m² (see drawings). The problem of keeping the delta structure to the original weight of the V2 can be solved by carrying the liquid propellants inside the wing structure. The weight of the flying-wing *Bumper* can therefore be broken down as follows:

airframe	1,820 kg
combustion chamber	420 kg
turbine pumps	330 kg
propellants for turbine	180 kg
servo mechanisms	250 kg
ethyl alcohol and water	3,585 kg
liquid oxygen	5,350 kg
WAC Corporal 5	310 kg
total	12,245 kg

The delta-wing rocket can be attached to the mother aircraft by means of two vertical pylons (see drawings), and would itself rest on a take-off trolley of the kind which is left behind on the ground. The whole combination would take off with the aid of JATO rockets housed in the trolley, with the *Bumper's* tanks empty (filled in flight).

The combination would have the following dimensions and weights:

upper wing (F-102A)	61 m²
lower wing *(Bumper)*	40 m²
aerodynamic lifting area	*101 m²*
gross weight of F-102A	11,000 kg
gross weight of rocket with empty tanks	3,000 kg
connecting pylons	500 kg
total take-off weight	*14,500 kg*
wing loading on take-off	143 kg/m²

The basic data for the calculation

A. Convair F-102A mother aircraft

Span	11.6	m	38	ft.
Length	19.5	m	64	ft.
Wing area	61	m²	658	sq. ft.
Gross weight (without weapons; with fuel for 90 minutes)	11,000	kg	24,200	lbs.
Take-off wing loading	180	kg/m²	37.8	lbs./sq.ft.
Sea level thrust of P&W J-57 P.11	5,000	kp	11,000	lbs.
Max. speed at 11,000 m (36,000 ft.)	1,500	km/h	930	m. p. h.
Ceiling	18,000	m	59,000	ft.

B. Bumper first stage (American version of V2)

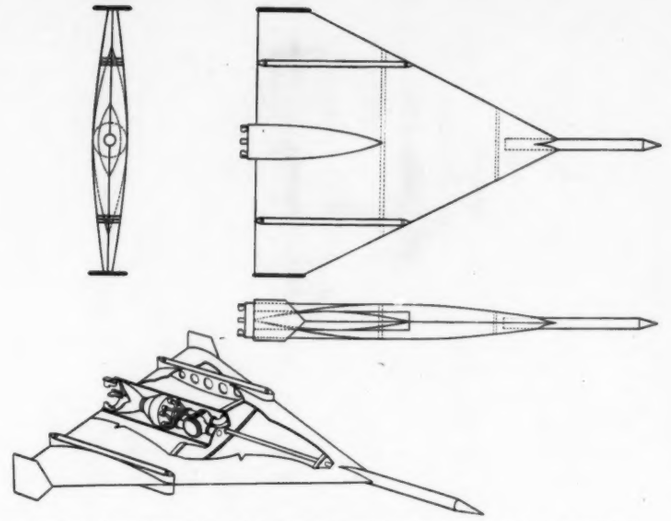
Length	14	m	46	ft.
Calibre	1.65	m	5.4	ft.
Tail span	3.6	m	11.8	ft.
Gross weight	11,935	kg	26,200	lbs.
Thrust (60 secs)	27,200	kp	60,000	lbs.
Specific impulse	183	sec	183	sec

C. Bumper second stage (WAC Corporal 5)

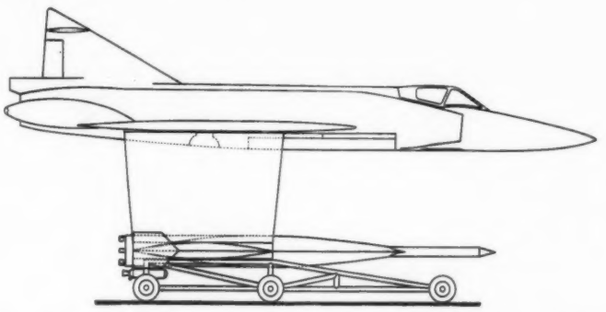
Length	4.9	m	16	ft.
Calibre	0.3	m	12	ins.
Gross weight	310	kg	680	lbs.
incl. solid propellant	150	kg	330	lbs.
airframe	138	kg	302	lbs.
instrumentation	22	kg	48	lbs.
Thrust (45 secs)	680	kp	1,500	lbs.
Specific impulse	200	sec	200	sec

D. Composite Bumper

Length	18.9	m	62	ft.
Gross weight	12,245	kg	26,880	lbs.
Burnout velocity				
of first stage	1,225	m/sec	4,000	ft./sec
of second stage	2,235	m/sec	7,350	ft./sec
Max. altitude	390	km	243	miles

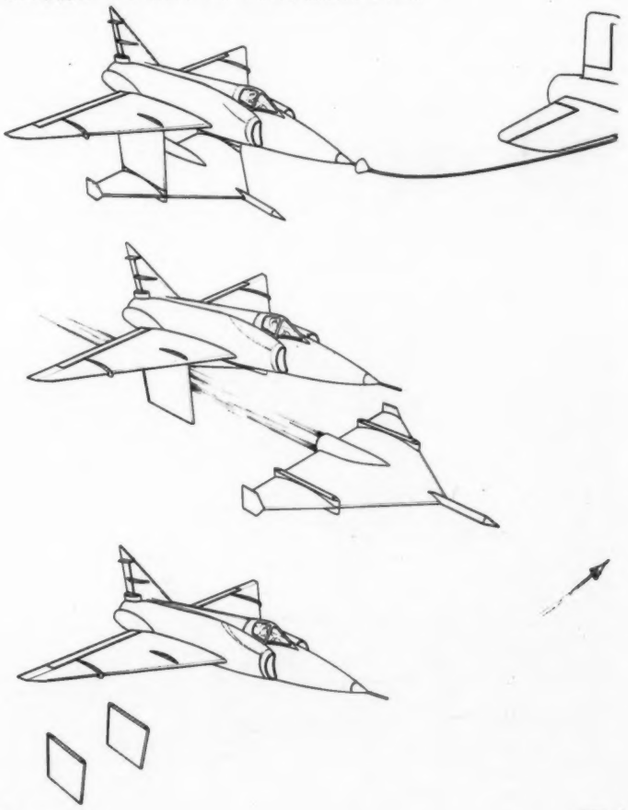


The *Bumper* is transformed into a flying wing aircraft with a span of 29.5 ft.: propellant tanks in wing; control by means of jet vanes.



Two robust pylons join the mother aircraft and the flying-wing *Bumper*, which in turn rests on a take-off trolley.

The three most important phases in launching a rocket from high altitudes: 1 – filling the *Bumper's* propellant tanks by the probe-and-drogue method; 2 – releasing the Bumper (at 14,000 m = 46,000 ft.) after ignition of the first stage; 3 – jettisoning the connecting pylons and return of the mother aircraft to base.



At the most favourable altitude a tanker aircraft would fill the *Bumper's* tanks with 4,200 litres of fuel and 4,700 litres of liquid oxygen, via a system of pipes passing from the aircraft's nose through the connecting pylons. After fuelling, gross weight will be roughly 23 tons, and max. wing loading 228 kg/m². The combination will then climb to 14,000 m, where the pilot will ignite the first stage of the rocket. As soon as the latter's thrust has reached a predetermined value, he will release the missile and initiate radio guidance. The rocket, steered by jet deflectors, follows the trajectory selected, which can be a "synergic" trajectory if the rocket is to reach a circum-terrestrial orbit.

Once the separation is complete, the pilot will jettison the connecting pylons and return to base.

*

The proposal I have put forward above is intended primarily as an invitation to a study of the general problem of carrying large rockets to a great height by means of aircraft. The combination of Convair F-102 and *Bumper* is therefore cited only as an example. It is possible to imagine many other "mother aircraft-rocket" combinations in which the conventional booster is replaced by a more suitable vehicle to cover the first 15 km in the atmosphere. No vehicle is better suited than the aircraft, since its specific consumption is about 15 times lower than that of a booster.

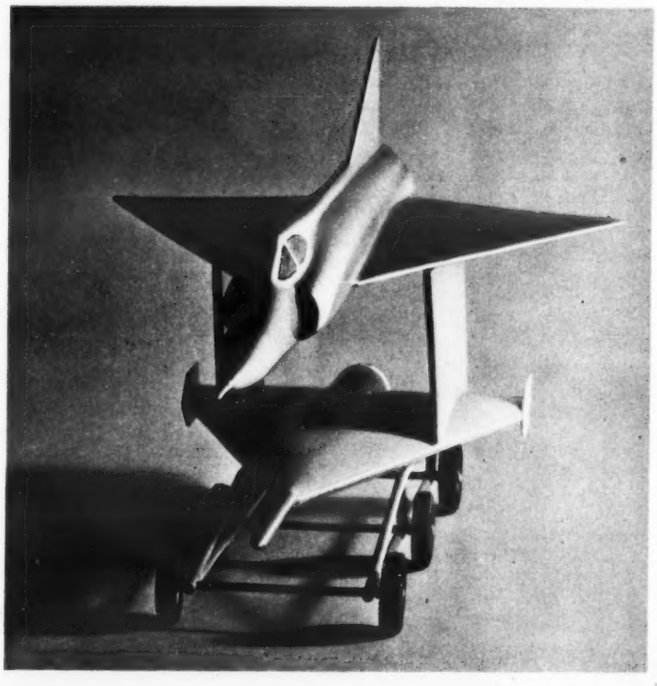
The last drawing illustrates another example of such a combination, that of two aircraft of suitable type carrying a delta-wing rocket weighing roughly 30 tons. Here, too, fuelling would be done in flight.

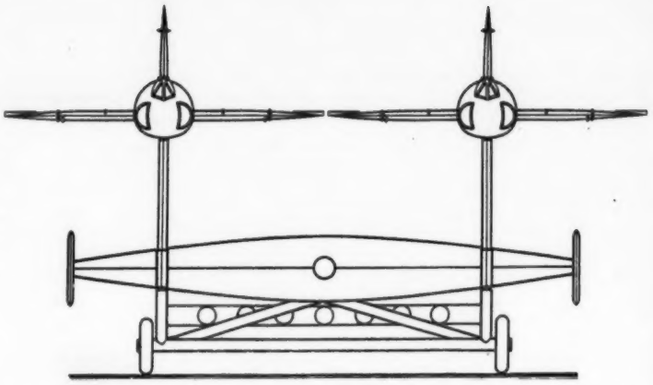
*

The major technical problems raised by my proposal will probably be the following:

1 — *Aerodynamic interference between the two wing surfaces.* As a biplane with an aspect ratio of less than 1 has no precedent in aeronautical practice, wind tunnel experiments will be necessary to determine the optimum position of the two wings in relation to one another. These experiments would present no great difficulty, since the biplane is clearly subsonic.

Robotti's composite biplane.





Even bigger multi-stage rockets – weight roughly 30 tons – could be transported to optimum launching altitude by two jet aircraft "in parallel."

2 — *In-flight fuelling.* The probe-and-drogue method is well known and is in current use in the U.S. Air Force. However, as two different propellants have to pass through the same pipes from the tanker aircraft to the rocket, provision must be made for the pipes to be washed out thoroughly after the passage of the first propellant and for the washing fluid to be emptied into the air.

3 — *Centre of gravity before and after in-flight fuelling.* It is possible to organize the fuelling in such a way that the centre of gravity travel remains within limits that will not endanger the stability of the whole combination.

4 — *Ice formation on the walls of the rocket tanks.* If liquid oxygen is used, it is highly probable that during the ascent to 14,000 m (which will take several minutes) the humidity in the atmosphere will condense on the walls of the tanks and give rise to dangerous ice formation. Here there are two possible remedies: either to use a different oxidizer or to provide thermal insulation for the tanks. Details can be left to the engineers to work out.

5 — *Take-off trolley.* There is no special difficulty in designing a trolley which will remain on the ground when the combination takes off. The trolley can be accelerated by a number of JATO rockets.

6 — *Manoeuvrability of the combination.* The aircraft's controls are not designed to steer the combination biplane. However, the latter is not required to carry out aerobatics, and all that is needed is a careful take-off from a runway of adequate length.

7 — *Connecting pylons.* The triangular configuration of the two wing surfaces offers a good basis for a robust attachment of the two connecting pylons. Nevertheless the pylons present one of the major design problems, since they have to permit release of the rocket and then themselves be jettisoned to enable the mother aircraft to land on its own undercarriage.

*

In conclusion, I believe that the composite vehicle consisting of an aircraft—either conventional or otherwise—and a rocket can find useful employment as carrier for a satellite to be placed in an orbit outside the earth's atmosphere. I would also stress, among the advantages of the proposed method, that of enabling launching from coastal areas or even above the open sea, where there would be no danger of damage being caused by the rocket stages on return to earth.

Finally, there is no need to emphasize the basic advantage of a piloted aircraft used as booster, namely that it does not have to be sacrificed after each launching but can be used a practically unlimited number of times.

Photographic reconnaissance of Rome . . . by the Italian Air Force. This picture of the heart of Rome was taken from a Republic RF-84F flying at roughly 20,000 ft., during a mass reconnaissance exercise by the 3rd Brigade of the Italian Air Force which began at dawn on October 9th, 1956 and covered wide areas of the peninsula. The main railway station (bottom left), the Colosseum, the Tiber and the Tiber island, the Pantheon and many other landmarks of the Eternal City are clearly recognizable. ▶

Space travel

The Surface-to-Surface Missile, Today and Yesterday

By Frederick I. Ordway, III, Executive Vice-President, General Astronautics Corp., Oyster Bay, New York

A surface-to-surface missile (or SSM) can be anything from a small solid-propellant anti-tank bazooka weapon with a range of hundreds or thousands of yards to intercontinental ballistic missiles (ICBM) capable of reaching targets 3,000 to 5,000 miles away. An SSM is launched from the surface, whether land or water, and is aimed at surface targets. The SSM is by far the oldest category of missile, while other newer types include air-to-surface, surface-to-air, air-to-air, upper atmosphere research missiles, and rocket powered piloted airplanes. And of course we must not forget fireworks, which for centuries have delighted adults and children alike.

There is little doubt but that the first SSM's were Chinese, and that they were used early for warlike purposes. From an 11th century document by *Wu Cling Tsung Yao* we know that black powder rockets were used in war. Known as *Huo Yao Pien Chien,* or fire arrow, this primitive rocket was of very short range and inaccurate. Fire arrow rockets continued to be mentioned for hundreds of years, and it appears that the Chinese became quite adept at rocketry, much to the displeasure of their enemies.

The Mongols often received the business-end of the Chinese rocket, and it was they who introduced the weapon to the Western world. Asian rocket successes were based on the barrage principle, numbers making up for inaccuracy. This concept has been used right up to the present day for many if not most combat operations where rockets have been used.

Following its introduction from Asia, both Moslem and Christian countries experimented with the rocket. From the 14th century onwards powder rockets were successfully used in battle on numerous occasions. The Italians, Europe's pyrotechnics experts, delighted in setting afire choice targets with rocket devices. And as the techniques of constructing, handling, and launching of rockets improved, so too did the powder charges become more efficient. A sort of crude propellant chemistry grew up.

By 1668 a German engineer named Cristof Friederich Geissler was experimenting with rockets weighing more than 100 pounds and incorporating an incendiary payload. Many military men were coming to believe that such rockets might soon replace the still poorly developed cannon and become the major artillery weapon for war. However, by the end of the 19th century the rocket had fallen into nearly complete oblivion. What was the reason?

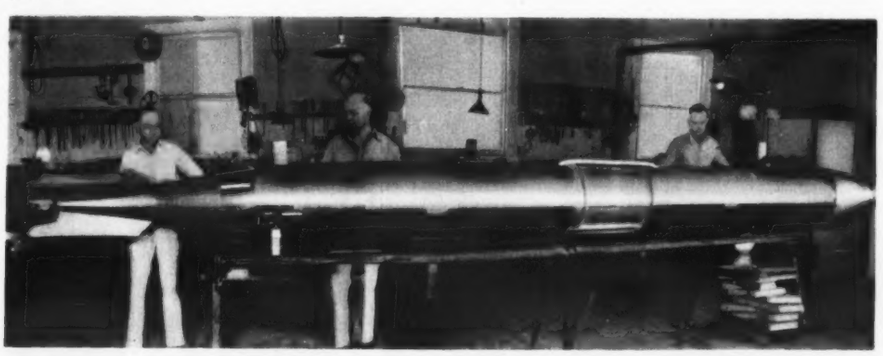
From Mysore to Woolwich

We must again turn to Asia, this time to the great sub-continent of India, to answer our question. There, towards the end of the 18th century, the British were soundly trounced by a smoothly run Rocket Corps of Hydar Ali, and later by his son, Tippu Sahib, of Mysore. At the Battle of Seringapatam, 1½-mile-range iron barrelled rockets roared into British positions with devastating effect. The sound was heard round the world.

William Congreve, like most Englishmen, was concerned with the goings-on in India, and he was especially interested in learning of the frightful weapon that was opening holes in British lines. Soon he was applying all his energies at the Royal Laboratory, Woolwich Arsenal, toward the scientific development of the Indian war rocket into a first-class piece of ordnance. He took the 6 and 12 pound Indian rockets and translated them into weapons that rapidly transformed many aspects of European warfare. Congreve, if not the father, is at least the grandfather of modern rocketry, and his work forms a dividing line in the history of a new discipline.

By 1805 Congreve had increased the effective range of his 6-pound rocket to over a mile, and during this same year his ship-to-shore missiles bombarded Boulogne, France. This was perhaps the first evidence of the value of the rocket missile to the Navy. Two years later Copenhagen received the fury of 25,000 Congreve rockets, again launched from Royal Navy vessels. Nor did the British limit themselves to ship launching; on land, this new, light, mobile rocket weapon proved popular (or unpopular, depending on the point of view) in the Battle of Leipzig in 1813. Once again Napoleon received a shattering blow

This liquid-fuel rocket was built by the American Physics Professor Robert H. Goddard in New Mexico in the spring of 1941 with funds provided by the Daniel and Florence Guggenheim Foundation. Though smaller, it resembled the German V-2 "reprisal weapon" in its operating principles. Goddard had started to experiment with liquid-fuel rockets in 1935.



The German Reinhold Tilling began to experiment with black powder rockets in 1928. The 8-cm calibre model shown reached a range of 2½ miles. In October 1933 Tilling lost his life when his laboratory blew up.

Subscriptions for yourself and your friends

will make sure that you get your copies of "INTERAVIA Review" regularly every month - Just fill out the enclosed order card and send it to Interavia's nearest agent or to your bookseller

Representatives :

Belgium	**Interavia, 5, Heidestraat Noord, Cappellenbosch-lez-Anvers.** Postal Cheque Account: 792.19 - INTERAVIA.
Canada	**Interavia, 25, Farmcote Rd., Don Mills, Ont.**
France	**Interavia, 144, avenue des Champs-Elysées, Paris 8me.** Postal Cheque Account : 5471-40, Paris.
Germany	**Interavia (Verlags-G.m.b.H.), Kaiserstrasse 1, Frankfurt/M.** Postal Cheque Account : Frankfurt/M. 1529 89.
Great Britain	**Interavia (U.K.) Ltd., 14, Clarges Street, London, W.1.**
Holland	**Henk A. Jansen, Olympiaplein 84, Amsterdam-Z.** Bank account : Interavia, Amsterdamsche Bank N.V., Amsterdam.
Italy	**Interavia, 30, Via San Marino, Rome 7.23.**
Japan	**Isogo, P.O. Box 3, Yokohama.**
Mexico	**Interavia, Ave. de los Alpes 1030-6, Lomas de Chapultepec, Mexico 10, D.F.**
South Africa	**Interavia, P.O. Box 10242, Johannesburg.** Bank Account : Standard Bank of South Africa, President Street, Johannesburg.
South East Europe	**Interavia, Postfach 192, Vienna I./1.** Postal Cheque Account : Österr. Postsparkassenamt, Vienna, No. 153.073.
Spain	**Interavia, Donoso Cortés 63, Madrid.**
Sweden	**Interavia, P.O. Box 29, Linköping.**
Switzerland	**Interavia, Corraterie 6, Geneva.** Postal Cheque Account : Geneva : I. 5360.
U.S.A.	**Interavia, 185 Madison Ave., New York 16, N.Y.**

SUBSCRIPTION PRICES

Countries	12 months	Currency	6 months	Countries	12 months	Currency	6 months
Austria . .	170.—	Sch.	90.—	Netherlands	25.—	H. fl.	13.—
Belgium . .	320.—	Fr. b.	170.—	Spain . . .	280.—	Pts.	145.—
Canada * .	7.00	U.S.$	4.00	Sweden . .	35.—	Kr.	18.—
France . . .	2400.—	Fr. fr.	1300.—	Switzerland	28.—	Fr. s.	15.—
Germany . .	27.50	DM	14.50	Union of **			
Great Britain	1. 15. 0	£	1. 0. 0	South Africa	2. 6. 0	£	1. 5. 0
Italy	4060.—	L. it.	2175.—	U.S.A.* . .	7.00	$	4.00
Japan * . .	7.00	U.S.$	4.00				

* two years $12.00 ** other Commonwealth countries £ 2.6.0 £ 1.5.0

Please enter my subscription **INTERAVIA** in English/French/German/Spanish * for ☐ 1 year ☐☐ 2 years ☐☐ 6 months

beginning with issue ____/19

Subscription fee ____ ☐☐ Check enclosed ☐☐ Please bill

Name :** _____

Address :** _____

Profession : _____

Employer : _____

For gift subscriptions :

This subscription has been ordered by :

Name and address :** _____

Profession : _____

Signature _____ Date _____

* Please check language desired. ** Please write in block letters.

INTERAVIA

Review of World Aviation

INTERAVIA

REVIEW OF WORLD AVIATION

Please fill in the address

The first operational long-range weapon, the German V-1 "Doodlebug" reprisal weapon used against England in 1944–45, was a small, pilotless, pulse-jet-propelled aircraft carrying a warhead of about 1,900 lbs. Its range was about 150 miles, its maximum speed about 400 m.p.h. Picture shows one diving on to London.

from the simple rocket whose roots spread from England to India and beyond.

Congreve's rockets grew in size, and their range and accuracy kept pace. Diameters were up to 6½ inches, weights to 42 pounds, and ranges to 3,000 yards. It was not long before the rocket grew right out of Congreve's laboratory and into the armies of nearly every European power. Rocket Brigades became popular for a number of reasons that are largely valid today.

First of all the rocket was inexpensive and, unlike an artillery field piece, did not require complicated launching mechanisms. Secondly, it could be handled easily and, because of its weight, was very mobile. Thirdly, though inaccurate, the rocket, if used in sufficient quantity, could unfold tremendous firepower. And finally, the Congreve rocket, like its tactical descendant, the *Bazooka,* posed no recoil problem, a fact that made it as popular with the Navy as with troops in the field.

The cannon and the rocket were often allies against a common enemy in the field of battle. On the ordnance development front, however, both have tried to jockey in a position of favour to the detriment of the other. For a long time both suffered from the accuracy standpoint, but once *rifled artillery* arrived on stage the rocket was quietly pushed into the closet, and the door was shut. An unguided, stick stabilized rocket was no match against the high-velocity spin-stabilized shell issuing from late 19th century cannons.

A New Impetus to the Surface-to-Surface Rocket

Despite the cannon, military rocketry did not stay "dead" long. When it came to life in the 20th century, it was not reports of Asian military successes that provided the catalyst . . . it was the dream of space travel.

Pioneer Russian, German, French, American and British researchers and theoreticians began to realize that only through application of the rocket principle lay the possibility of one day travelling to the Moon and planetary objects beyond. Space travel, however, is another story, and is mentioned only in terms of the impetus it gave the surface-to-surface military rocket weapon. Largely because of the vision of astronautical scientists, a long series of rocket tests began in the 1920's and '30's, carried out for the most part by attic and Sunday-afternoon experimenters. Slowly, but surely solid and newly-discovered liquid rockets began to take shape, both in Europe and in the United States. Possibly for the first time in history the rocket was being developed solely as a device for peaceful purposes.

The Military Takes Over in Germany

By the time rocket motors had reached at least some degree of reliability in Germany (following a rather brief period of private experimentation by the German Space Flight Society) the Army stepped into the picture, and the rocket once again took on military significance. What the Nazi military machine started at Kummersdorf in 1932 led directly to the Peenemünde rocket development station on the Baltic and the deadly V-2 bombardment rocket of 1944-45.

After World War II the U.S. Navy made a large number of copies of the V-1, called it *Loon* and used it for training. This one is at the Navy's Air Missile Test Station, Point Magu, Calif.

Investigators from the space flight society, locally known as the VFR, formed the nucleus of the German military development programs. Many types of missiles were investigated, and of those that became operational the A-4 (or V-2) "vengeance" SSM was assuredly the most outstanding. Preceded by a number of relatively small rockets, the V-2 took shape as the war in Europe unfolded from 1939 to 1945. When one recalls the almost primitive stage of rocketry (particularly liquid propellant rocketry) in the 1930's, it is indeed amazing that a 14-ton monster like the V-2 could be operational by 1944. The development of this rocket ranks as one of the great scientific and engineering achievements of all time.

One might call the V-2 an SRBM (short range ballistic missile). It could reach targets 150 to 200 miles away and attain propellant-burnout speeds of over 3,000 miles per hour. Part of its trajectory was outside the main mass of the Earth's air blanket; thus, in some ways the V-2 was man's first space vehicle.

Well over 4,000 V-2's were fired before the end of the war, of which more than 1,000 were used against London. When the British first felt the results of the 2,000-pound V-2 payload, they were only partially astonished, for they had an inkling of what was to come. For one thing, an experimental V-2 had misfired and strayed over to Sweden. Furthermore, Winston Churchill, in his remarkable book *Closing the Ring,* spoke of how following a heavy British raid on Peenemünde the Germans moved some important testing facilities over to Poland. One V-2 seemed to have fallen near the Bug River without exploding, and the alert Poles beat German patrols to it, pushing it into the river. When the Germans had stopped searching for the missile, the Poles pulled it out and notified the British, who secretly landed a plane and took off one hundred pounds of key components. An interesting sidelight on war, espionage and rocketry.

The V-1 "Buzz Bomb" was another surface-to-surface missile, but it was pulse-jet and not rocket-propelled. Today we would call it a cruise missile, and because of its low speed (about 400 miles per hour) it would be vulnerable to surface and air-launched counter weapons. A high percentage of the many thousands fired were knocked out before reaching their targets. The United States, incidentally, made a large number of copies of the V-1, called it the *Loon*, and used it to train military personnel in missile firing and handling operations.

Both the V-1 and V-2 burned liquid propellants, but the *Rheinbote* was a solid propellant SSM that received operational status. Approximately 50 of these four-stage, 37 foot rockets were fired against continental targets towards the close of the war. Depending on the payload, its range was about 140 miles.

Spectacular and advanced as were so many of Germany's operational SSM's, some of the designs and projects under active investigations seemed in 1945 to be almost unbelievable. One was an ICBM, although it was not so termed in those days. Known as the A-9/A-10, the German ICBM was to be a two-stage affair capable of reaching a top speed of more than 6,000 miles per hour and of hitting targets on the East Coast of the United States. The A-9 was to be a modified delta-winged version of the V-2 and was to be boosted to some 2,700 miles per hour by an 87-ton A-10. At a specified altitude of between 30 and 40 miles the A-9 would commence a long, supersonic glide to its objective. The project was not followed up throughout the war largely because of more important immediate objectives, such as the V-2 and a series of anti-aircraft missiles.

As for small tactical SSM's, German ordnance developments were not spectacular, and in fact American, British and Russian efforts here certainly rivaled anything done by the Nazis. A *Nebelwerfer* rocket launching device fired either six 15-cm shells or larger 21-cm shells, at ranges up to four miles. The W.G.R. 41 rocket was also fired from the Nebelwerfer for laying smoke screens and for depositing high explosives on tactical targets. Bazooka-like devices included the *Panzerfaust* and *Panzerschreck,* both larger than contemporary American designs and less accurate.

The Barrage Rocket and the Guided Rocket

Historically, the military rocket has been employed for close support of infantry operations, although, as we have seen, it has also seen service as a naval close range bombardment weapon. Due to its inherent wide dispersion, its success has stemmed chiefly from the saturation effect achieved by large numbers.

Rockets are still used for saturation operations, and very successfully. We recall, however, that Congreve's rockets moved out of favor during the latter part of the 19th century because of the advent of successfully rifled artillery. Since artillery competed so successfully, accuracy-wise, what made the military once again look at the rocket, first for tactical, and later for strategic use?

Artillery, while it could compare favorably with relatively clumsy, unguided missiles in 1870, could hardly do so forever. The cannon may reach far behind the enemy lines, and do so with astounding accuracy, but there are limits. To increase range, we must increase the muzzle velocity, and this means bigger guns, less accuracy, materials problems, not to mention the difficulty of rapid transport and setting up operations.

A rocket, on the other hand, solves many of these problems. As it contains its own propelling charge, no elaborate firing mechanisms are necessary, and many weight and mobility problems disappear. The rocket increases in velocity from the time it leaves the launcher, its highest speed being reached at the time of propellant burnout. In general, we can say that the range of a rocket will depend on the amount of propellant it can carry, and increased ranges can therefore be bought merely by carrying more charge.

Rocket specialists realized quickly that, while ranges might be almost indefinitely extended, accuracy would be hard to come by. The rocket motor fires over a good part of the trajectory, and the missile (unlike the artillery shell) starts off relatively slowly, increasing its speed until propellant exhaustion. These circumstances made flight predictions most difficult, and something had therefore to be done to influence the missile *after* launch. This meant guidance, and much of the history of the surface-to-surface missile from the 1930's was closely tied to in-flight control.

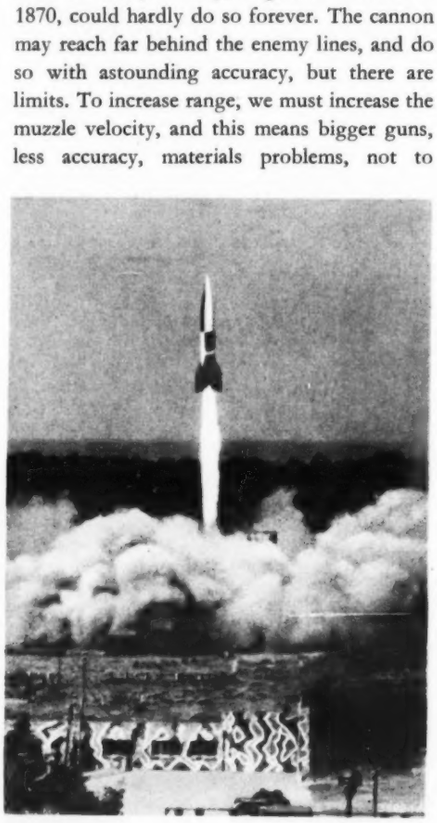
A number of things can cause a missile to deviate from a pre-computed course. Its motor's thrust-line may not be perfectly centered. Local atmospheric conditions, unpredicted side, tail or head winds etc., may act to alter the plotted course, while the missile may not be an exact aerodynamic duplicate of the one on which trajectory calculations were made. In order to compensate for these and other factors, methods had first to be developed to *detect* any errors and deviations, and then to *correct* them.

To these basic reasons for guiding rocket propelled surface missile weapons, another soon came to be added. As warfare became more mobile, and fast moving tanks, vehicles of all sorts, and airplanes entered the picture, it became desirable to be able to track an evasive target. If a missile could "follow" an evading target, its dominance over artillery would be staggering.

Figuratively and literally, a lot of ground has been covered from the 40-pound Congreve rockets to the 28,000-pound V-2, from ranges of a few thousand yards to hundreds of miles. Angular errors that could be tolerated for short range rocketry would be unacceptable for modern missile tactics. A barrage operating over small distances is one thing, but for specific target destruction involving a minimum expenditure of firepower and for intermediate and long range missions, the flight path of the missile must somehow be controlled.

Both barrage and guided missiles have their place in the nature of war, and although the

The first liquid-fuel combat rocket, the German V-2 (or A4), was fired against Southern England in hundreds in the last stages of World War II. Range was about 200 miles, explosive charge about 2,000 lbs., accuracy was doubtful. This one is being fired from the Peenemünde rocket research establishment.



A solid-propellant German surface-to-surface missile was the *Rheinbote*, a three-stage affair with a large booster, of which about 50 were fired against land targets at the close of the war. Range was up to 140 miles.

emphasis today is understandably on guidance, we must not forget the inherent practicality of the barrage. Burchard[1], an officer of the United States Seventh Fleet in World War II, said (in answer to the assertion that barrage rockets were relatively ineffective against enemy barges): "... it doesn't make much difference whether we get a direct hit or not. The Japs have got so that as soon as we open up with rockets, they all go overboard. Then we can come up along-side and sink the barge with automatic weapons fire, or chop a hole in the bottom with a hatchet."

The Key to Accuracy: Guidance

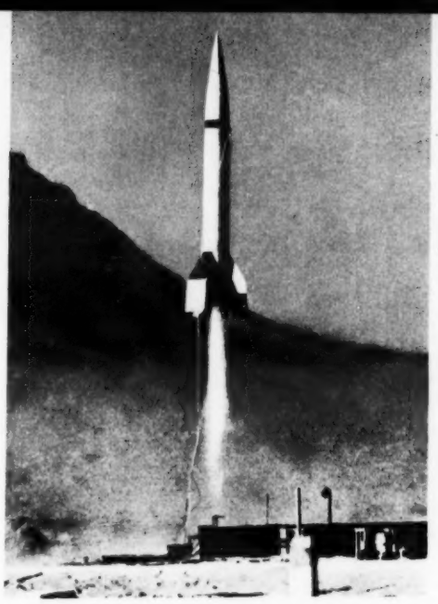
Two things must be achieved before a missile can be successfully guided to a target. First, it must be controlled with respect to its *attitude* in space. Second, there must be effective and if possible permanent control of its flight path or trajectory. Without attitude control, however, there can be no trajectory control for obvious reasons.

The attitude of a flying surface-to-surface missile is controlled by controlling its movements in yaw, pitch and roll. Gyroscopes are conventionally used to establish angular errors between a fixed reference plane within the missile and the missile's position in space at any given instant. Error signals have then to be amplified and transmitted to a servomechanism that will actuate the appropriate aerodynamic control surface on the missile, such as ailerons, rudder or elevator.

For flight path control, guidance is generally required during three phases, i. e., the launching phase, the midcourse phase, and the terminal phase. The normal guidance system will include devices or apparatus to sense, compute, direct, stabilize and to actuate aerodynamic surfaces, although during the launching operation a guidance means such as a tower or rail may be employed. This however, is external to the missile. The more common guidance methods are:

a. radio navigation systems;
b. magnetic reference;
c. gravitational reference, inertial guidance
d. celestial reference;
e. beam-rider guidance;
f. command systems;
g. homing devices;
h. wire control.

Radio navigation, beam-riders, command, homing and wire control systems are all electromagnetic in nature, and take advantage of signals transmitted from a control station to the missile. In the case of wire control, which the Germans investigated in World War II and which the French and Americans are now extensively developing for anti-tank use, signals are relayed along wires that unwind as the missile flies forward.



The Convair MX-774 rocket of 1946 – 47 powered by an 8,000-lb. thrust four-chamber Reaction Motors rocket engine, probably represented the first serious U.S. advance into the ballistic missile field. Three were fired for upper air research.

Radio navigation systems such as Loran can be used effectively, basic ingredients being ground transmitting stations and a computer in the missile itself. Beam riders actually follow some sort of radar or even light beam that is locked on the target. In a command guidance system two radar trackers are used, one that follows the progress of the target and one that follows the missile. A ground computer detects errors in the flight path of the missile in terms of the desired intersect course, and transmits this knowledge to the missile control system, allowing the flight path to be appropriately altered.

Homing devices are generally used for terminal guidance phases. Here, the missile has within itself the necessary sensing apparatus to respond to some characteristic of the target, such as light, radar, or heat emanations. There are semiactive, active and passive homing systems. In the first case, energy is transmitted from a source external to both the missile and target. For example, radar beams from a ground station could bounce off a target and be detected by the missile. The missile's computer would predict the course of the moving target, and the control mechanisms would properly align the missile's collision course. An active homing system refers to the case when a missile sends out energy, illuminates the target, and receives the reflected energy from which its computer plots the instantaneous flight path. A passive homing guidance system has no transmitter, either in a ground station or in the missile. The energy that emanates from the target, which could be a large steel mill, would be received by the missile and again a computer would "inform" the servomechanisms what aerodynamic control surfaces should be deflected to maintain the proper course. Such a missile could home in on energy in the form of light, heat, radar-radio waves, or even sound.

Long-range surface-to-surface missiles, whether cruise or ballistic types, are likely to employ either terrestrial or celestial reference or straight radio command. The latter is undesirable, however, because of jamming possibilities, and the fact that the enemy would know when the station is operative and hence possibly programming missile flight towards his bases. And, of course, air, ship or land based radio and radar stations could be destroyed.

An inertial gravitation system is completely free from the activities of a real or potential enemy, and in fact relies on nothing but the gravitational field of the Earth. An inertial system is simply a motion measuring system, every increment of motion being integrated with time to determine the distance travelled along the flight path. It is obvious here that accelerations in terms of inertial space are most important. In some cases a terrestrial reference guidance system is used wherein a programmed flight path is incorporated into the missile's control system. An inertial system can only be used against fixed targets, or at least against targets that do not move from the time the attacking missile is launched.

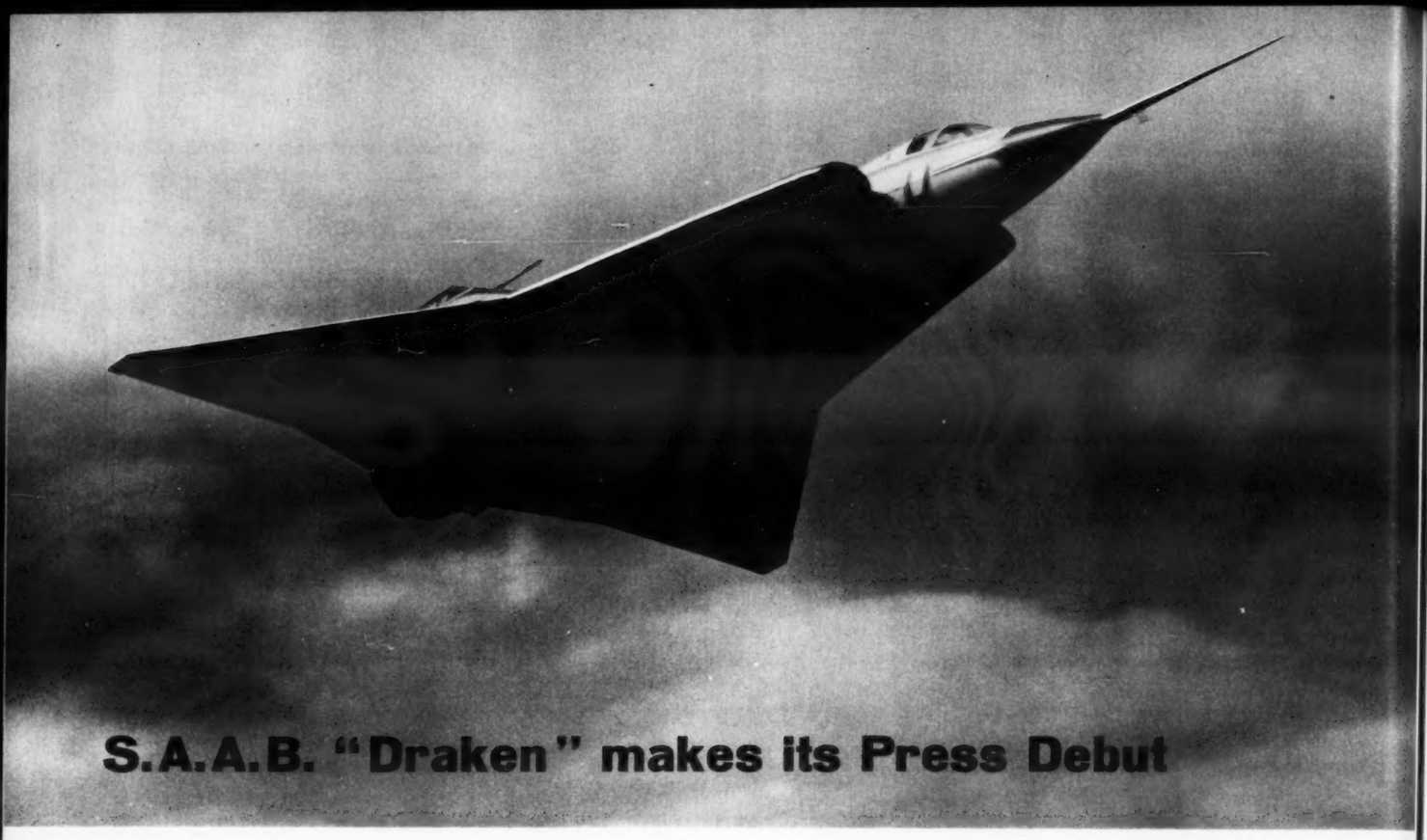
For long-range missile guidance, celestial navigation techniques can profitably be linked to the inertial system, giving us an inertial-celestial guidance system. Here the stars are used to provide the needed space reference for the automatic celestial navigation missile system. A drawback for the use of the celestial system is that daylight flights within the atmosphere, and bad weather (relatively low altitude) flights at night would be impossible. Furthermore, during polar operations when the sun is permanently above the horizon, stars will not be observable, and hence the system would not operate.

The type of guidance best suited to the SSM will depend on many things. Is the target 5,000 feet or 5,000 miles away? Is it moving or stationary? Does it give off any energy, so that a homing mechanism could be used? What is the minimum CPE tolerable in terms of known warhead destructibility and the target size? How important is the target? What type of missile is being used, and what other means are at hand to neutralize the target should the missile(s) miss?

There are many types of guidance, all of which have advantages and disadvantages. Some are further developed than others; all are slowly being perfected for specific uses.

(To be continued)

[1] *Rockets, Guns and Targets*, OSRD Report on Science in World War II, ed. by J. E. Burchard, Boston, Little, Brown & Co., 1948, p. 132.



S.A.A.B. "Draken" makes its Press Debut

The Saab-35 *Draken* in a climb.

The Swedes have repeatedly astonished the world by the way in which they keep their Air Force supplied with modern aircraft adapted to their own special requirements. Although the country has a population of only about 8,000,000, Sweden has since World War II mostly managed to design, develop and produce its own fighters and attack aircraft just in time when they were needed and only rarely has had to import foreign aircraft as a stop-gap solution.

Last October Saab Aircraft Company, of Linköping, Sweden's only aircraft manufacturing company, demonstrated its latest product to the press—the Saab-35 *Draken* all-weather fighter (Swedish Air Force designation J 35). The aircraft has been ordered into quantity production, and deliveries are to begin "within the next few years". This gap no doubt was the reason why the Air Force ordered a number of Hawker *Hunters* for interim duty.

Newsmen were surprised by a variety of features when they saw the three J 35 prototypes on the ground and in the air at Linköping, Saab's main plant. First, the type's "double-delta" wing, adopted by Saab after exhaustive wind tunnel studies and tests with a piloted research aircraft (the Saab-210), attracted much attention. Second, the aircraft demonstrated that it is supersonic in level flight (at about 23,000 ft. = 7,000 m). Third, it showed off remarkably short take-off and landing runs as well as unusual manoeuvrability and climb performance. Finally, the *Draken* was revealed as something of a light-weight fighter of 8 to 9 tons a.u.w. (depending upon armament alternatives) compared with the 10 to 18 tons of other modern fighters.

The Saab-35 *Draken* is the result of a Swedish Air Force requirement issued in 1949 for an aircraft capable of intercepting bombers in the transonic speed range. Preliminary project work at Saab was centred on a fighter with a low aspect ratio delta wing because this promised reduced drag and sufficient volume for fuel, armament, equipment, etc. However, with a conventional delta wing the aircraft's centre of gravity would have been aerodynamically unsatisfactory and would have

Two *Draken* prototypes showing off their double-delta wing planform.

Draken shortly after take-off.

Cockpit of *Draken* is slightly drooped to provide better visibility during landing at high angle of incidence.

required the lengthening of the forward fuselage. At this point the "broken" or "double delta" idea was conceived.

This wing form was quite new at the time, and Saab investigated its qualities by a variety of means: by the Saab-210 jet-propelled experimental aircraft, swing-line models, by tests in a transonic wind tunnel completed in spring 1952, in water tank flow studies of precision-built steel models (costing up to U.S. $20,000 each), etc. The development of the Saab-35's aerodynamics took two to three times the man hours needed for its predecessor, the Saab J 32 *Lansen* all-weather fighter, because the new aircraft had to be calculated for three speed ranges, subsonic, transonic and supersonic. Special, light measuring and registration equipment was designed for testing of the first prototype. This equipment weighed about 1,100 lbs (500 kg) and is capable of taking and registering several hundred measuring values per second.

Other new features of the type are a light-weight high-pressure hydraulic system with a pressure of 210 kg/cm², more than double that of the Saab J 29 jet fighter; complete servo-operation of the controls with synthetic "feel" being fed into the stick; and integral fuel tanks.

The first prototype of the J 35 made its maiden flight at Linköping on October 25th, 1955. Few details of the aircraft have so far been disclosed beyond the facts that it is powered by a Rolls-Royce *Avon* (built under licence by Svenska Flygmotor) with an afterburner, that it will be armed with guns, rockets and guided missiles, and that it is equipped with a Saab-designed ejector seat and a landing parachute.

Saab Chief Test Pilot Bengt R. Olow in *Draken* cockpit. Note ejector seat and *(left)* one of the sharp-lipped air intakes.

The men behind the Saab-35 *Draken*. *Left to right:* Chief Test Pilot Bengt R. Olow; Erik Bratt, *Draken* project engineer and the man mainly responsible for the design of the aircraft; Trygve Holm, Saab Managing Director; Lars Brising, Director of Aircraft Engineering; Tord Lidmalm, Chief Engineer, Aircraft Design; Hans-Erik Lövkvist, Chief Engineer, Theoretical Analysis Dept.; Kurt Lalander, Chief Engineer.

Small fins have been added ahead of the main fin and rudder. There is no horizontal tailplane; "elevons" are fitted to the wings.

The Saab-210 research aircraft with the "double-delta" wing. In front of it Olle Klinker, Saab Assistant Chief Test Pilot; Chief Test Pilot Bengt Olow; and K. E. Fernberg, Experimental Test Pilot.

What's in the Air?

Extracts from Interavia Air Letter, *daily international news digest, in English, French and German. All rights reserved.*

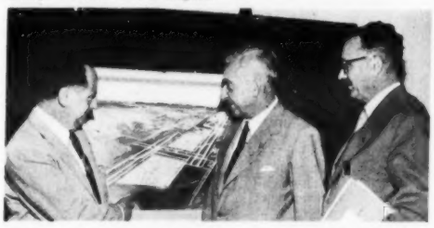
AIR TRANSPORTATION

● **The I.C.A.O. Air Navigation Conference,** meeting in Montreal, revised its international standards and recommended practices dealing with the airworthiness of aircraft. The new standards are supplemented where necessary by "acceptable means of compliance" to show by example the level of safety required. The Conference also set up a system by which I.C.A.O. could provide guidance to member states on the latest technical thinking in the field of airworthiness. On the question of rearward facing seats for commercial transports delegates were unable to reach a unanimous decision. Requirements for aircraft external lights, intended among other things to reduce the possibility of mid-air collisions, were considered, and the Conference was of the opinion that a special panel of experts should be called to discuss this problem in greater detail.

● **British Overseas Airways Corporation** has received authorization from the Government to buy fifteen Boeing 707 jet transports with Rolls-Royce *Conway* engines. The intercontinental version which B.O.A.C. will receive is 153 ft. long and has a span of 143 ft. Its maximum all-up weight will be 295,000 lbs., and maximum landing weight 195,000 lbs. It will carry from 107 to 170 passengers according to layout, and its cruising speed will range from 525 m.p.h. depending on range. Total cost is roughly $132,000,000, of which $98,000,000 must be paid in American currency. The purchase will be financed by means of a British bank dollar loan and an increase in the Corporation's borrowing powers. The new aircraft will be used on routes between Britain and the east coast of the United States, Canada, the U.S. west coast (presumably across the Arctic) and—provided the Government agrees—between Britain and Australia (across the North Atlantic, the United States and the Pacific).

● **British European Airways** will build a large new hangar at London Airport for servicing its *Vanguard* fleet. It will cover an area of 500,000 square feet and will more than double the Corporation's existing hangar space at the airport. The new building, which is due to be ready for occupation in 1958, will be on two floors with underground stores linked to groundlevel workshops by a number of large lifts. A concrete apron will run through the main building, with 10 bays for major aircraft overhaul on one side and five bays for general maintenance on the other side.

Swissair Board Chairman Dr. Rudolf V. Heberlein (centre) and President Dr. Walter Berchtold (right) take over the company's first Douglas DC-7C at Santa Monica. Left, Donald W. Douglas.



Swiss officials visit the United States for discussions on the airport problem. Woodruff de Silva, Los Angeles International Airport manager (left), explains his airport's expansion plans to H. Hürlimann, President of Flughafen-Immobiliengesellschaft Zurich-Kloten, and Dr. E. Altorfer, Director of the Air Transport Office (far right).

Britain's Institute of Navigation has awarded its Gold Medal for 1956 to Harvey F. Schwarz and William J. O'Brien of Decca Navigator Co. Ltd. in recognition of their services in the development of the Decca Navigator System. Picture shows Harvey F. Schwarz receiving the medal from Captain A.M.A. Majendie, the Institute's President.

● **The Statistical Handbook of Civil Aviation, 1956,** just published by the Civil Aeronautics Administration, U.S. Department of Commerce, gives a detailed survey of American aviation trends in recent years. Almost every figure for 1955 shows a marked increase over the preceding year. The domestic scheduled airlines in 1955, for example, flew 19,800,000,000 passenger-miles, compared with less than 16,800,000,000 passenger-miles in 1954. This is three times as many passenger-miles as were reported by railroad parlor and sleeping cars. Only five years ago the airlines and railroads were dividing this traffic equally.—Aircraft manufacturers in 1955 had the best year since 1948, turning out 4,820 new civil aircraft. The number of civil pilots reached the total of 724,638.

● **An average of 86 civil aircraft** a day flew across the North Atlantic during July and August 1956. This means that about once every sixteen or seventeen minutes a passenger aircraft, either scheduled or non-scheduled, was taking off for a trans-Atlantic flight. Of the 5,337 trips during July and August, U.S. scheduled airlines flew 2,373 and all the foreign carriers combined 2,412. As was the case last year, Pan American led with 1,449 flights, Trans World Airlines was second with 924, and the nearest foreign carriers were Scandinavian Airlines System with 378, British Overseas Airways Corporation with 324 and Air France with 305.

INDUSTRY

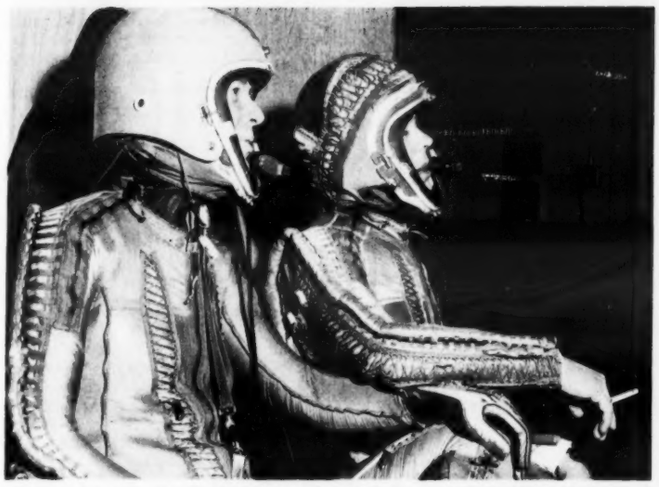
● **Finmeccanica,** Società Finanziaria Meccanica, the company which administers the Italian Government's financial interests in the engineering industry, has appointed a new Board of Directors. New Chairman is Balduccio Bardocci. The company's accounts for the 1955–56 financial year to June 30th closed with a surplus of 95,000,000 lire, as against 61,000,000 lire the preceding year. Funds made available by I.R.I. totalled 1,725,000,000 lire, compared with 549,000,000 lire in the 1954–55 year. During the year under review Finmeccanica invested fresh capital in a number of companies engaged in the production of aircraft and aeronautical equipment, including IMAM-Aerfer (500,000 lire), Alfa Romeo (1,275,000,000 lire), Marconi Italiana (300,000,000 lire), Società Italiana Radio Marittima (181,412,000 lire) and Sara-Elettronica (40,000,000 lire).

● **A wind tunnel** for flow speeds of up to Mach 2 has recently been put into operation by the Max Planck Society's Institute for Flow Research in Göttingen. The tunnel operates according to the vacuum storage principle and has a 30×30 ins. test section making possible trials with aircraft and wing models with a span of up to approx. 20 ins.

● **Five major American aircraft manufacturers** hold firm orders or options for 600 jet and turboprop passenger airliners, the Aircraft Industries Association reveals. The orders are valued at more than $2,000,000,000 and have been placed by both domestic and foreign air carriers. A total of 259 of the transports, valued at $323,500,000 are turboprop powered, and the remaining 341 are all four-engine jet transports costing $1,741,000,000. More than 100 of the 600 gas-turbine transports have been ordered or optioned by foreign airlines.

Shin Mitsubishi Heavy Industries has been granted a licence to build 70 North American F-86F *Sabres* for the Japanese Air Force. The assembly shed at the Komaki plant.

Model of Vienna-Schwechat Airport after expansion. Centre, the two-storey terminal building with access for passengers (upper sotrey) and baggage (ground floor). To its right the restaurant wing, left the operational and office wing with control tower.



Mel Ross (left) and Lee Lewis, both U.S. Navy, have reached the record altitude of 76,000 ft. in a pressure car suspended from a free balloon. Previous record 72,000 ft.

De Havilland Aircraft of Canada Ltd. is building a hundred CS2F-1 *Tracker* anti-submarine aircraft for the Royal Canadian Navy, under Grumman licence. The *Tracker* is to operate from Canada's new aircraft carrier, the *Bonaventure*. Max. endurance eight hours.

● **Squadron Leader Neville Duke,** 34, one of Britain's leading test pilots, has been forced to give up test flying because of recurrent spinal trouble caused by a flying accident. He relinquished his appointment as Chief Test Pilot with Hawker Aircraft Co. on October 31st. His successor is A. W. Bedford, 35, who has been with Hawkers since 1951 as Assistant Chief Test Pilot.

● **Vertol Aircraft Corporation** has initiated what it describes as "an aggressive sales programme" in an attempt to increase its foreign sales. Arrangements have been completed for sales representation in almost every Western European country, as well as Peru, Venezuela and Japan. According to Harry S. Pack, Vice President of Consumer Relations, Vertol is anticipating commercial as well as military sales.

● **Bell Aircraft Corporation** has split its Niagara Frontier Division into two operating divisions. One group will be known as the Aircraft Division and will be headed by Vice President Julius J. Domonkos. The other will be called the Weapons Systems Division under Roy T. Sandstrom, Vice President and General Manager. The Aircraft Division will be responsible for design and production of aircraft and will be in charge of sub-contracting. The Weapons Systems Division will have four separate units to be known as the avionics, rockets, guided missiles and research groups. The reorganization is the second of a series of moves to establish completely integrated divisions. Bell recently established a separate Helicopter Division to handle all activities in that field.

● **"Portrait of the Earth"** is the title of a twenty-minute documentary film in colour produced by Hycon Aerial Surveys Inc., Pasadena, Calif.

GUIDED MISSILES

● **Aberporth missile test base** on the Welsh coast north of Cardigan, has been shown to British journalists for the first time. It was first used about 1939, but its full expansion did not start until some time after World War II. The site covers 250 acres, and the bay is free from shipping or other interference. The establishment has been directly under the Royal Aircraft Establishment for some eight years and employs over 400 people. Both air-to-air and ground-to-air firing is carried out; aircraft and radio controlled targets are operated from an R.A.F. airfield some distance away.—One of the most interesting firing bases is the Clausen Rolling Platform, the only one of its kind in the world. It is a 750-ton 60-ft. boat-like structure complete with a triple barrel launcher and control radar as on an actual ship installation. The "boat" is set in a concrete pond at the foot of the cliffs, and electric motors operating hydraulic pumps give any pitch and roll motion found on a ship at sea. Beneath the deck is a complete set of rooms with control equipment, instruments, etc., as there would be for instance on a guided weapons cruiser. The upper deck is cleared for firing, but the internal "ship's" rooms are fully manned. The C.R.P. is operated by the Royal Navy, with a crew of 4 officers, 20 ratings and four Naval scientific officers, who refer to it as "HMS Rock and Roll". To supply stores and test vehicles etc. to the C.R.P. a funicular railway has been cut in the cliff, the platform of which can carry 30 tons. It takes 11 minutes from the cliff top to the platform.

Philco AAM-N-7 *Sidewinder* air-to-air missile with infrared homing head.

● **The Salto di Quirra missile test centre** in Sardinia was opened on October 29th. The first weapons to be tried there were Contraves Italiana's Oerlikon 1954 rocket and a C7 air-to-air rocket of the Centro Studi per la Propulsione a Reazione.

● **Lulu** is the name of an American anti-submarine missile, the existence of which has not yet, however, been officially confirmed. Despite the Pentagon's reticence, Vice Admiral W. V. Davis Jr., Chief of Naval Operations for Air, referred to the development of *Lulu* in a speech to the Aviation Writers Association. Davis pointed out that the *Lulu* has a lethal range of several miles and is capable of being exploded at the great depths which modern submarines can reach. It can be launched from an aircraft or a surface ship.

TECHNICAL

● The *Republic F-105B Thunderchief* supersonic fighter-bomber recently began flight testing. Fitted with a Pratt & Whitney J-75 jet, it is reported to be capable of speeds of Mach 1.5. Its design takes the area rule into account.

● The U.S. Air Force's *Douglas B-66 Destroyer* jet bombers can now be refuelled in flight by the probe and drogue method. The necessary equipment has been fitted in all the B-66Bs and RB-66Bs built at Douglas' Long Beach plant and in the B-66Cs produced by the Tulsa Division.

● New guided missile designations were mentioned by U.S. Secretary of the Army Wilber M. Brucker at the annual dinner of the Association of the U.S. Army in Washington. The Army's anti-aircraft units in the continental United States are

E. H. Moncrieff, President of Standard Aero Engine Ltd., of Winnipeg (left), hands over the chairmanship of the Air Industries and Transport Association of Canada to J. G. Notman, O.B.E., President and General Manager of Canadair Ltd., Montreal.

Lieutenant General A. Baretta, Chief of the Netherlands Air Staff, retired on November 1st. He has been succeeded by Major General M. Schaper (right), who was at the same time promoted to Lieutenant General.

Mockup of Northrop's Project N-102 light-weight supersonic fighter. Though designed several years ago, the prototype was never completed.

Northrop TZ two-seat supersonic trainer.

Prototype of the Cessna 620 executive transport with four Continental GSO 526-A flat-six engines of 250 h.p. take-off power each.

now for the most part equipped with *Nike Ajax* rockets. Good progress has also been made in the development of the *Nike Hercules* (new designation for the *Nike B*), which is superior to the *Nike Ajax* in range, manoeuvrability, max. altitude and speed.

● The second prototype of the *Martin P6M Seamaster* four-jet combat flying boat crashed near Delaware City on November 9th. The four membres of the crew were able to bail out.—As Thomas S. Gates, Assistant Secretary of the Navy, recently announced, thirty *Seamasters* have so far been ordered.

● A wooden mockup of the *Vickers Vanguard* has been built at Vickers-Armstrongs Ltd.'s Weybridge factory. The first prototype should be ready for flight testing in the autumn of 1958.

● *Hawker Aircraft Limited* is working on the design of a supersonic fighter with a top speed of 1,800 m.p.h., as a purely private venture. It is to be designated *Hurricane* and to be ready for flight testing in 18 months.

● *Rolls-Royce RB.106* is the name of a new British jet engine with extremely low weight-to-power ratio. Designed for a thrust of approx. 3,000 lbs., it is to power a Royal Canadian Air Force elementary trainer under development at Canadair Ltd.

● The Australian firm of *Kingsford Smith Aviation Services Pty. Ltd.*, of Bankstown, N.S.W., has developed an agricultural biplane, the PL-7 *Tanker*, with short nacelle-like fuselage, twin rudder unit and fixed tricycle undercarriage. The prototype began flight testing a few weeks ago. The PL-7 is fitted with a 400 h.p. Armstrong Siddeley *Cheetah 10*, has a gross weight of 5,000 lbs. and a cruising speed of 112 m.p.h. Price of production model about £10,500.

● *Hamilton Standard* has been awarded a U.S. Civil Aeronautics Administration type certificate for a propeller with hollow aluminium blades. The propeller, which has been under development for six years, will be fitted, for example, in the Lockheed L-1649A *Super Constellations* ordered by T.W.A. and Deutsche Lufthansa and in the Lockheed *Electras* ordered by K.L.M. The new blade is made from an aluminium forging, heated to 800°F (430°C) which is first placed in an 8,000-ton forging press, then extruded into a finned tube in a 5,200-ton extrusion press. Finally the tube is flattened and twisted, anodized internally and externally, filled with synthetic sponge and coated with nickel for protection against abrasion damage.

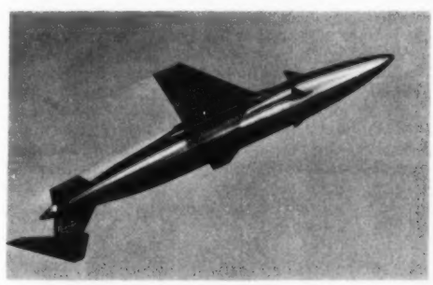
● Speaking at the annual dinner of the Navy League, Secretary for the Navy Charles E. Thomas revealed first details of a projected *85,000-ton super carrier* to be powered by a turbine driven by eight atomic reactors. Speed will be 33 knots, and the atomic fuel carried will be sufficient to take the carrier several times round the world. Use of atomic power removes the need for funnels and hence the conventional superstructure. In addition, the elimination of fuel tanks for the vessel's motors enables substantially larger quantities of aircraft fuel to be carried.—Design of the vessel is already complete, and construction can begin in the next fiscal year if Congress grants the necessary funds.

● The *Turboméca Gabizo* turbojet, equipped with a SNCAN afterburner, is being tested at high altitudes aboard an English Electric Canberra bomber. During these tests the Canberra has climbed to 53,600 ft; the Gabizo afterburner functioned completely satisfactorily. – The contract for development of the afterburner was awarded to SNCAN by the Service Technique de l'Aéronautique early in 1955. The Turboméca Gabizo jet, with SNCAN afterburner, is to power several light ground-attack aircraft now under development.

● A *transonic wind tunnel* for flow speeds of Mach 0.7 to 1.65 and with a test section of 16 x 16 ins has now been completed by *Société Ouest Aviation* (formerly SNCASO) after 14 months spent in construction work and 4 months in equipment. Designed for intermittent operation with stored compressed air, the installation can be used for measurements of 10 to 20 secs duration. A 120 h. p. pump loads the compressed air container to the required working pressure of 140 psi in 15 to 20 mins.

● *Curtiss-Wright Turbolectric propellers*, which are used in the Boeing YC-97J Turbofreighter (four 6000 hp P&W T-34s) and the Douglas C-133A (also four T-34s), have been authorized by the Military Air Transport Service for 1100 hours between overhauls; a further extension to 1500 hours is expected in the near future. The hollow steel blade propeller is the first to operate 300 hours without periodic inspection.

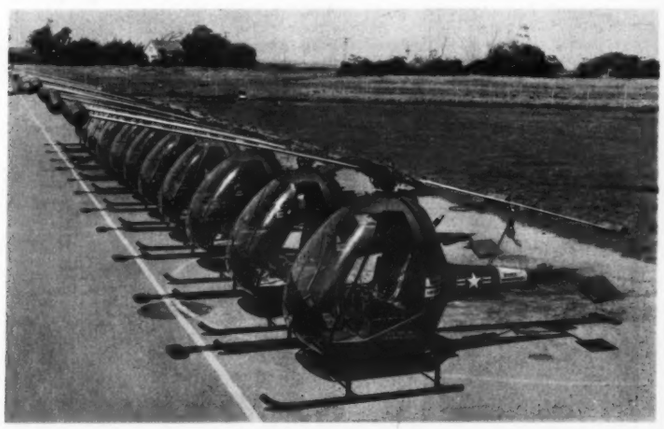
● A self-propelled *salvage crane* with a lifting force of 18 tons was demonstrated at the Paris Motor Show by *Etablissements Willeme*. The four-axle vehicle is equipped with a hoisting tackle supplied by the firm of Applevage and is powered by a 220 h. p. engine, which gives it a speed of 50 mph. Max. permissible weight during movement 176,000 lbs. The vehicle is operated by two men, a driver and a crane operator.



Radioplane RP-70, a new rocket-powered target drone for operational exercises with weapons systems in the Mach 0.9 speed range.

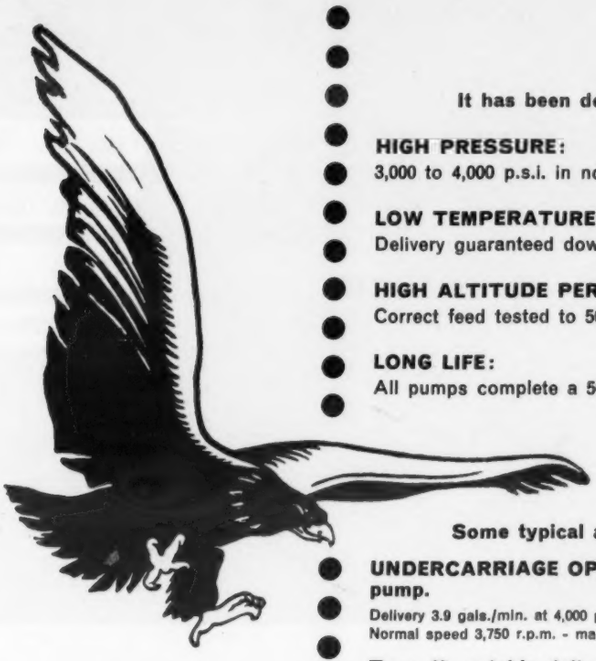
Convair B-58 *Hustler* supersonic combat aircraft.

The first Hiller H-32 jet-powered helicopters have been delivered to the U.S. Army.



There is a Messier Pump to meet each of your needs

PEMA 680



It has been designed to ensure:

HIGH PRESSURE:
3,000 to 4,000 p.s.i. in normal service

LOW TEMPERATURE RELIABILITY:
Delivery guaranteed down to —40° C

HIGH ALTITUDE PERFORMANCE:
Correct feed tested to 50,000 ft.

LONG LIFE:
All pumps complete a 500-hour test

Some typical applications:

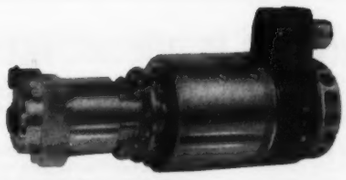
UNDERCARRIAGE OPERATION: Type 33 variable delivery pump.
Delivery 3.9 gals./min. at 4,000 p.s.i. - 5.3 gals./min. at 3,000 p.s.i.
Normal speed 3,750 r.p.m. - max. speed 4,000 r.p.m.

Type 40 variable delivery pump - delivery 0.9 gals./min. at 3,000 p.s.i.
Normal speed 6,850 r.p.m. - max. speed 7,100 r.p.m.

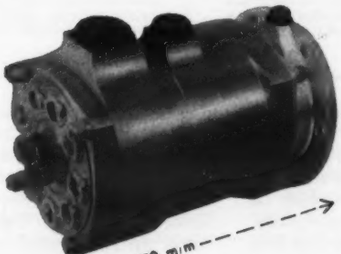
SERVO CONTROLS: Self-regulating electric pump.
Normal delivery 0.45 gals./min. at 3,000 p.s.i. - Normal speed 3,500 r.p.m.

Constant delivery pump -
normal delivery 0.9 gals./min. at 2,000 p.s.i. Normal speed 5,000 r.p.m.

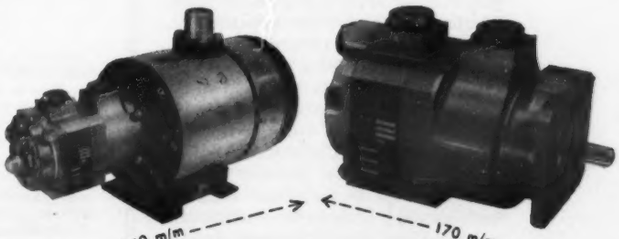
If none of the 20 types of MESSIER pumps already in service meet the SPECIAL PROBLEM you have to solve, MESSIER will design the NEW PUMP you require in 6 MONTHS.



Electric pump
Delivery 0.5 gals./min. at 4,650 r.p.m.
under a pressure of 1.920 p.s.i. (Mystère IV)



Self-regulating pump
Delivery 5.3 gals./min. at 3,750 r.p.m.
under a pressure of 3,000 p.s.i.



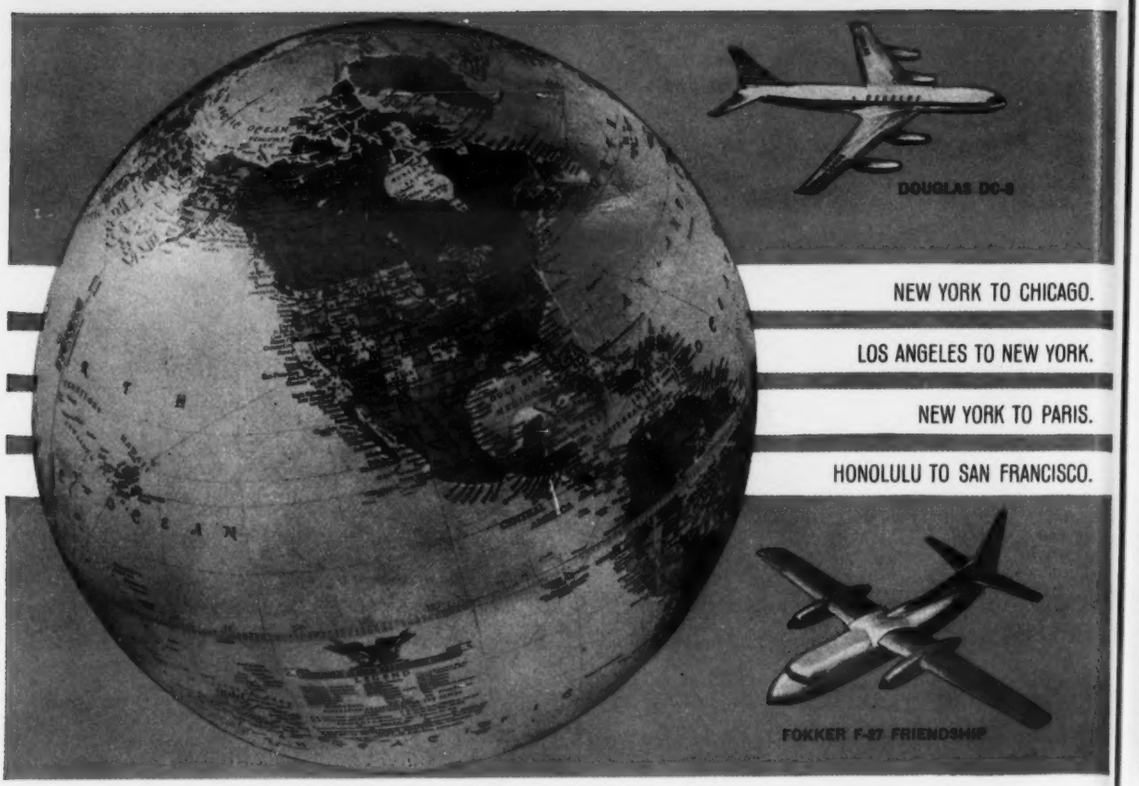
Electric pump
Delivery 0.9 gals./min. at 6,850 r.p.m.
under a pressure of 3.000 p.s.i. (Fouga 170 S)

Self-regulating pump
Delivery 0.9 gals./min. at 6,850 r.p.m.
under a pressure of 3,000 p.s.i.

MESSIER

Specialists in undercarriages and high pressure circuits

58, RUE FÉNELON - MONTROUGE (Seine) - ALÉ. 22-36



Jet airliners shrink globe . . .

When you and your family board these new jet airliners, you'll be stepping into a completely new era of transportation designed to get you where you are going faster, more comfortably and more dependably. To appreciate the progress that has been made, following are some exclusive jet problems that had to be licked and some original answers to those problems worked out by Bendix Aviation Corporation.

For example, the starting, generating and ignition systems used on reciprocating engines were not applicable on jets. One of our new Bendix jet starters, small enough to put in a breadbox, produces 450 h.p. to crank a giant jet engine 1800 r.p.m. in three and a half seconds.

Igniting a jet is like lighting a match in a tornado. An ordinary spark has no chance. New Bendix jet ignition produces a super spark that fires jet engines immediately.

Jets are fuel hogs with very sensitive digestive systems. Not too much, not too little—the mixture's got to be just right. Speed, temperature and altitude affect this mixture. Thus, fuel-air proportions must be changed rapidly and automatically. New Bendix* fuel-metering and engine control systems are precise and automatic, take another tough problem off the crew's backs.

Jet speeds necessitate more accurate navigation and piloting. Here several exclusive Bendix devices team up for greater precision: The

ADVANTAGES OF THE JET AGE WILL BE JET PROBLEMS—HAS

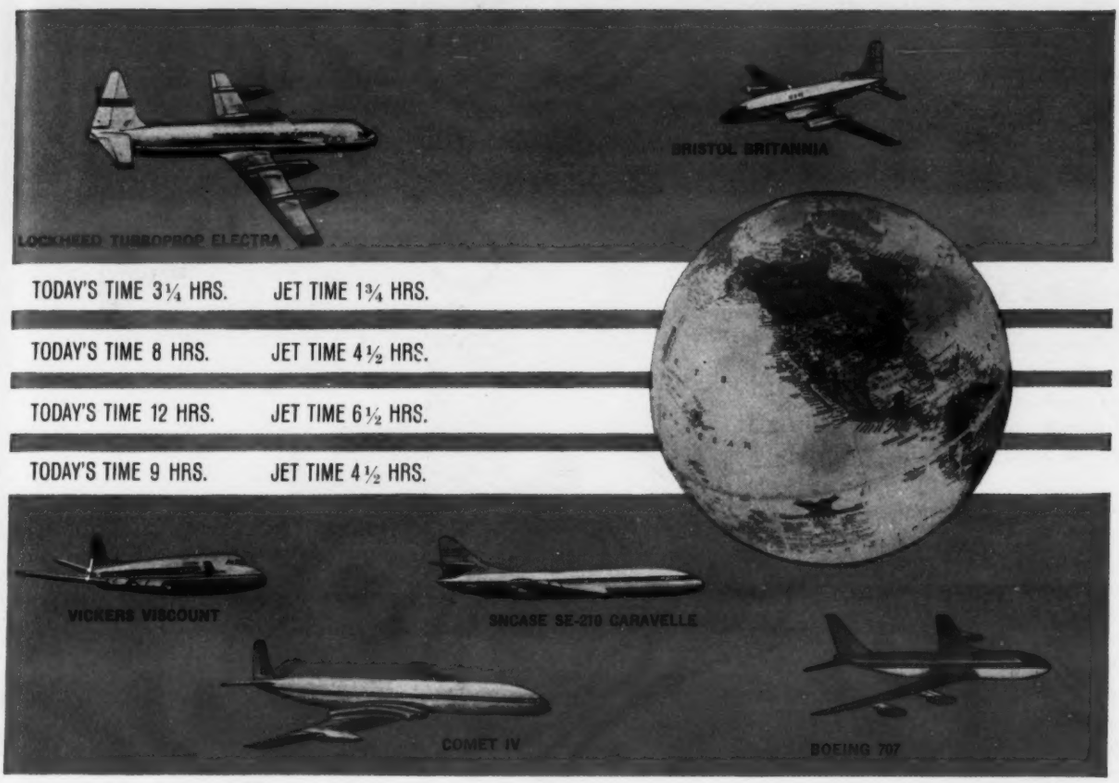
COMPLETE TRANSISTORIZED NAVIGATION AND CONTROL SYSTEM
Includes automatic pilot capable of automatic landing approaches; Flight Director systems; heading reference systems.

AIRBORNE RADAR SYSTEM
Sees storms 150 miles away and shows how to avoid them for smoother ride.

RADIO COMMUNICATION SYSTEM
Including receivers, transmitters, flush antennae, radio compass, radio magnetic indicators, marker receivers, glide slope receivers, VOR-localizer receivers, Omni-mag indicators, cockpit loud speaker, distance measuring equipment, transponder beacon and selective calling, passenger address and transistorized interphone systems.

LIQUID OXYGEN SYSTEM
Automatic high-altitude oxygen system for passengers plus flight crew oxygen system.

SPECIAL INSTRUMENTS
To measure Mach airspeed and fuel flow; accelerometers; specially lighted turn-and-bank and rate-of-climb indicators.



will cut travel time in half!

YOURS SOONER BECAUSE BENDIX ANTICIPATED THESE DEVICES READY NOW

COMPLETE LANDING GEAR
Including wheels, brakes, shock absorbers and "Cerametalix" brake lining—our special friction material developed for stopping jets.

TURBINE STARTERS
Originated by Bendix to solve the problem of starting jet engines.

AC GENERATING SYSTEM
Including fault-detecting and regulating devices and inverters.

RELIABLE, RUGGEDIZED ELECTRON TUBES

JET IGNITION SYSTEM
Provides extra hot spark for starting and high altitudes.

FUEL-METERING AND ENGINE CONTROL SYSTEM
Provides proper air-fuel mixture at all speeds, temperatures and altitudes.

HYDRAULIC CONTROLS
For raising and lowering landing gear, applying boost power to control surfaces. Includes servo-valves, accumulators, positioning actuators, pressure reducers, relief valves, hand pumps, flow dividers and cylinders.

Polar Path* compass, which made polar navigation practical and which is equally accurate anywhere; the Flight Director, a simplified navigation system in which two instruments replace many; and the first completely transistorized automatic pilot which will not only fly jets with more exactness than human pilots but automatically bring them in for pinpoint landing approaches.

Ordinary brakes and lining can't stop the fast, heavier jets. New Bendix* jet airplane brakes and our special Cerametalix* friction material licked the stopping problem. New Bendix* landing gear and shock absorbers set them down softly.

Airborne radar to spot storms ahead, surveillance radar to help control airport traffic, G. C. A. radar for bad weather landings, a complete line of ground and air radio communications systems and automatic liquid oxygen systems are some of the other proven devices we have ready now for passenger jets.

This is probably the most complete package of equipment ever offered a new industry by one supplier

Bendix has hundreds of products for other fields, also. Write for "Bendix and Your Business".

**Trademarks of Bendix Aviation Corporation*

Bendix International

Division of Bendix Aviation Corporation
205 East 42nd Street, New York 17, N.Y., U.S.A.
Cable "Bendixint" N. Y.

Featherweight Champ!

ARC's ADF weighs less than 20 lbs!

Why carry dead weight ? Why excess bulk ?

This Automatic Direction Finder offers accuracy and reliability proved in more than two years of testing—yet the entire 5-unit systems weighs only 19.7 pounds. Now you can have a DUAL installation where required—at a weight saving of 80 pounds or more.

The ADF still is the world's Number One navigational aid, usable on an estimated 60,000 radio stations. Now you can have ADF featuring ARC standards of performance and reliability. This system incorporates hermetic sealing of critical components such as the entire loop assembly. It also has other mechanical features designed and tested for dependability under today's higher speeds and more exacting operational and environmental conditions.

The Type 21 ADF covers all frequencies from 190 kc to 1750 kc. It requires less power—only 2.8 amps at 27.5 volts dc input. Extremely low drag of the loop is an outstanding feature. Housing extends only 2 inches from the skin of the aircraft.

Now make room for more payload and other equipment. Fly with ARC-reliability, less weight, less space, less drag. Ask your dealer for complete details.

TYPE 21 ADF WEIGHS ONLY 19.7 POUNDS

Component Units Weights: Receiver, 6.8 lbs.; Loop, 4.3 lbs.; Loop Housing, 0.5 lbs.; Control Unit, 1.6 lbs.; Indicator, 1.3 lbs.; Power Unit, 5.2 lbs.;
CAA Type Certificated

Dependable Airborne Electronic Equipment Since 1928

Aircraft Radio Corporation BOONTON, NEW JERSEY

Omni/ILS Receivers—Course Directors—UHF and VHF Receivers and Transmitters—LF Receivers and Loop Direction Finders — 10-Channel Isolation Amplifiers — 8-Watt Audio Amplifiers — Interphone Amplifiers — Omnirange Signal Generators and Standard Course Checkers — 900-2100 Mc Signal Generators

Please address all communications to our exclusive export representatives (except Canada): Sterne, Carr & Farr Company, 425 Fourth Avenue, New York 16, New York, U.S.A., cable address: " Staraero ".

The C-123 can't land on a postage stamp . . .

but almost any clearing is its landing field

On almost any clearing—almost any field—you can safely land the Fairchild C-123 assault transport.

Actual short-field tests have demonstrated that the rugged C-123 is able to take off and land from *deeply eroded, sandy fields;* that it can work from unprepared clearings *under downwind conditions;* that it is capable of mass landings into ungraded "combat zones" . . . *at 8-second intervals.* And literally thousands of flights have proven that the C-123 requires *no more than 700 ft. for takeoffs and landings.* During these strenuous tests, no C-123 was lost, none was damaged.

What better proof of the C-123's near-universal assault and logistics capability?

FAIRCHILD

AIRCRAFT DIVISION • HAGERSTOWN 10, MARYLAND

A Division of Fairchild Engine and Airplane Corporation

. . . WHERE THE FUTURE IS MEASURED IN LIGHT-YEARS!

Ram Air Turbines

Ram air turbine accessory drive units are being developed by Rotol to provide a source of independent electrical or hydraulic power for the operation of essential flying controls under conditions of emergency.

ROTOL

GLOUCESTER ENGLAND

PUB/R/30/56

Space travel

Can Man Reach Distant Celestial Bodies ?

BY PROFESSOR J. ACKERET,
FACULTY OF AERODYNAMICS,
FEDERAL INSTITUTE OF TECHNOLOGY, ZURICH

Foreword : The majority of the following remarks were written several years ago, but remained filed away as the prospects of achieving very high speeds (comparable with that of light) seemed to me to be altogether too vague.

Meanwhile, however, similar studies, some of them going even further, have been published elsewhere [1], *and interest in the no longer so new "paradoxes" of the special theory of relativity has grown. As the path followed here avoids the introduction of new concepts, readers may welcome its exposition, even if it brings nothing basically novel to light. — The problem of producing the high exhaust speeds will be discussed briefly at the end of the article and should therefore not cause too much concern at the start.*

It is a favourite mental exercise among popular writers to endow space travellers with the speed of light and then resignedly comment that a human life is long enough to reach only the very nearest fixed stars [2], but that more distant objects will remain permanently out of our reach.

This conclusion is theoretically incorrect insofar as, under the (special) theory of relativity, even the greatest finite distances shrink for an observer in a space vehicle travelling near the speed of light, so that even distant nebulae can be "visited" in principle during a normal human life.

[1] *E. Sänger :* "Zur Theorie der Photonraketen", Ingenieur-Archiv, Berlin 1953, Vol. XXI, pp. 213-226.

[2] Listed in *Russel; Dugan, Stewart,* Astronomy Vol. II, p. 632, Boston 1927.

True, the vehicle would have a speed *very close* to that of light, which would require high accelerations ; these would pose physiological problems, quite apart from the tremendous energy involved. It will thus be necessary to examine these conditions with particular care.

*

In order to avoid unnecessary complications, we have simplified the problem as follows : the space vehicle would start from a fixed base (earth) and move in a straight line towards its distant target, whose speed relative to the earth is ignored. Braking would then begin at mid-trajectory and continue until zero speed is reached again, at the target. During the return journey everything would take place in the opposite order.

A careful definition must obviously be made of the systems of coordinates and the clocks on which lengths and times are based. Distance measured from the earth will be given here as x, and time by an earth clock as t. For the space traveller distances measured from the space vehicle are x' and time by a clock of the same make t'.

At the beginning of the journey both clocks —on the ground and in the vehicle—show the same time ($t = t' = 0$). In ordinary mechanics t always remains equal to t' ; in relativity mechanics, however, the position is different.

The speed of the spaceship (in the earth system) is given as v. It increases constantly from zero to a maximum value very close to the speed of light c.

Forces of gravity can be ignored. For those who dream of the speed of light such forces are mere bagatelles, and in fact the field of gravity rapidly falls to minute quantities as distance increases. Speed v is also considered to vary *slowly*, so that accelerations b are not so great that the vehicle's occupants would not survive them.

*

Changes in distance and time, as observed on the one hand by an observer on earth and on the other by the space traveller, can be compared by means of the *Lorentz transformation* (*equations 1 and 2* ; formulae on following page — Ed.)

If we introduce speeds u and u' (equations *3a* and *3b*)—namely for a particle which can move even in relation to the rocket — equation *2* becomes *4*, and the relativistic addition theorem gives equation *5* and hence *6*.

The two latter equations enable acceleration (in the earth-bound system) to be calculated, with speed v at present being considered as constant. This gives an expression as in equation *7a*, which can also be written in the simpler form *7b*.

Processes on board the spaceship must also be examined more closely. Though the space traveller (mass point m) does not accelerate in relation to his vehicle, he should be under the influence of an apparent gravity mb. This means that the spaceship itself must accelerate in such a way that the inertial effect of mass m becomes exactly equal to mb.

We can thus write $(\dot{u})' = b$ and ignore u' in equation *5* and in the denominator of equation *7b*, so that $\dot{u} = \dot{v}$, and equation *7b* is transformed into *8a*. The latter can also be written in the form of *8b* and after integration (with $v = 0$ at $t = 0$) gives *9a*. If *9a* is resolved over v/c we get *9b*, which shows that even over a very long period of time the vehicle speed cannot exceed the speed of light.

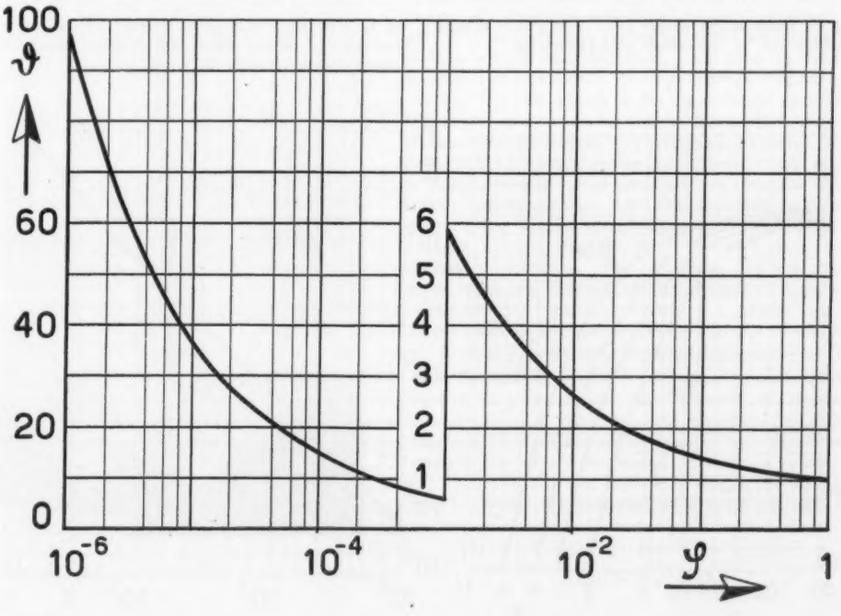
Seen from the earth, the rocket accelerates at a decreasing rate and takes a very long time to approach the speed of light.

*

Turning now to the space vehicle's system of coordinates, equation *6* becomes *6a* for $u' = 0$, and equation *8b* is replaced by *10*. If the latter is integrated it gives equation *11* or — resolved over v/c — equation *12*.

Equation 12 reveals that the ratio of the vehicle's speed (measured from the earth) to the speed of light (sometimes known as Einstein's number) is equal to the hyperbolic tangent to the quotient of the speed as measured aboard the vehicle (acceleration times vehicle time) and the speed of light. *Thus a different relationship from that in equation 9b appears.*

Fig. 1 : Relativistic time dilatation ϑ ("earth time" to "vehicle time") for various speed conditions $\varphi = 1 - v/c$.



(1) $dx' = \frac{dx - v\,dt}{\sqrt{1 - v^2/c^2}}$

(2) $dt' = \frac{dt - \frac{v}{c^2}\,dx}{\sqrt{1 - v^2/c^2}}$

(3a) $\frac{dx}{dt} = \dot{x} = u$

(3b) $\frac{dx'}{dt'} = (\dot{x})' = u'$

(4) $\frac{dt'}{dt} = \frac{1 - \frac{v}{c^2}\frac{dx}{dt}}{\sqrt{1 - v^2/c^2}} = \frac{1 - \frac{vu}{c^2}}{\sqrt{1 - v^2/c^2}}$

(5) $u = \frac{u' + v}{1 + \frac{vu'}{c^2}}$

(6) $\frac{dt'}{dt} = \frac{1 - \frac{v}{c^2}\frac{u' + v}{1 + vu'/c^2}}{\sqrt{1 - v^2/c^2}} = \frac{\sqrt{1 - v^2/c^2}}{1 + vu'/c^2}$

(7a) $\dot{u} = \frac{du}{dt} = \frac{(1 + \frac{vu'}{c^2})\frac{du'}{dt'}\frac{dt'}{dt} - (u' + v)\frac{v}{c^2}\frac{du'}{dt'}\frac{dt'}{dt}}{(1 + \frac{vu'}{c^2})^2}$

(7b) $\dot{u} = (\dot{u})' \frac{(1 - v^2/c^2)^{3/2}}{(1 + vu'/c^2)^3}$

(8a) $\dot{v} = b(1 - v^2/c^2)^{3/2}$

(8b) $b\,dt = \frac{dv}{(1 - v^2/c^2)^{3/2}}$

(9a) $\frac{b\,t}{c} = \frac{v/c}{\sqrt{1 - v^2/c^2}}$

(9b) $v/c = \frac{bt/c}{\sqrt{1 + (bt/c)^2}}$

(6a) $\frac{dt'}{dt} = \sqrt{1 - v^2/c^2}$

(10) $b\,dt' = \frac{dv}{1 - v^2/c^2}$

(11) $\frac{b\,t'}{c} = \frac{1}{2}\ln\frac{1 + v/c}{1 - v/c}$

(12) $v/c = \tanh\left(\frac{b\,t'}{c}\right)$

(13) $\vartheta = \frac{2\,v/c}{\sqrt{1 - v^2/c^2}\ln\frac{1 + v/c}{1 - v/c}}$

(1a) $dx = \frac{dx' + v\,dt'}{\sqrt{1 - v^2/c^2}}$

(1b) $dx = \frac{v\,dv}{b(1 - v^2/c^2)^{3/2}}$

(14) $x = \frac{c^2}{b}\left\{\frac{1}{\sqrt{1 - v^2/c^2}} - 1\right\}$

(15) $x = \frac{c^2}{b}\left\{\cosh\frac{b\,t'}{c} - 1\right\}$

(16) $x = \frac{c^2}{b}\left\{\sqrt{1 + \left(\frac{bt}{c}\right)^2} - 1\right\}$

(16a) $\left(x + \frac{c^2}{b}\right)^2 - c^2t^2 = \frac{c^4}{b^2}$

(15a) $\xi = \left(\frac{c}{\beta_0 S}\right)\left\{\cosh\frac{\beta_0 S\tau'}{c} - 1\right\}$

(17) $\xi \cong \frac{1}{\beta}\left\{\cosh\beta\tau' - 1\right\}$

(12a) $\varphi = 1 - v/c = 1 - \tanh\beta\tau'$

(18) $\mu_1 = \left(\frac{1 - (v/c)_{max}}{1 + (v/c)_{max}}\right)^{1/2}$

(19) $\mu_{tot} = \mu_1^4 = \left(\frac{1 - (v/c)_{max}}{1 + (v/c)_{max}}\right)^2$

(20) $\mu_{tot} = \mu_1^2 = \frac{1 - (v/c)_{max}}{1 + (v/c)_{max}}$

If now Einstein's time dilatation t/t' is written as θ, we get equation *13* — independent of b — and can plot time dilatation against v/c or $1 - v/c = \varphi$ in the form of a curve (cf. *fig. 1*). *This curve reveals that no perceptible effects of relativistic time dilatation can be expected until the speed of light is approached very closely.*

*

To ascertain the distance covered, we start from the inverse formula to *equation 1*, in the form shown in *1a*. Assuming $dx' = 0$ (no motion inside the rocket) the result, obtained with the aid of equation *10* (for dt') is equation *1b*. Integration (with $x = 0$ for $v = 0$) gives equation *14*, from which *15* can be derived with the aid of *12*. Here it should be noted that equation *15* turns into the classic value $x = 1/2\ b\ (t')^2$ at the beginning of the motion.

Equations *14* and *9b* give *16*, which can also be written as in *16a*. Converted into a distance-time diagram, *16a* gives a hyperbola. We have here *Born's hyperbolic motion.*

*

Let us now introduce other terms. Acceleration b is taken as equal to βg, where g is the earth's gravity acceleration (981 cm/sec²), times are expressed as relative to the number of seconds per calendar year ($S = 3.15 \times 10^7$ sec) and distances measured as fractions of light years (1 light year $= c \cdot S = 9.45 \times 10^{17}$ cm).

Under these conditions we can write " earth time " as $\tau = t/S$ and the corresponding " vehicle time " as $\tau' = t'/S$. Also, distance in light years becomes $\xi = x/cS$, so that *equation 15* can be expressed as *equation 15a.* If we then substitute the figure values for g, c and S, we get *approximately the simple formula shown in equation 17.*

This function is shown in graph form in *fig. 2* for four values of β. This diagram thus shows the distance covered in light years during the acceleration period (with 1g, 1.5g, 2g and 3g) as a function of " vehicle time ".

In the same way equation *12* can be converted into *12a*, whose evaluation (for the same four values of β) is shown in *fig. 3.*

On the subject of *figs. 2* and *3* it should be noted that four times the vehicle time τ' is required for a complete round trip and that the distance of the destination planet from the earth is equal to $2\,\xi$.

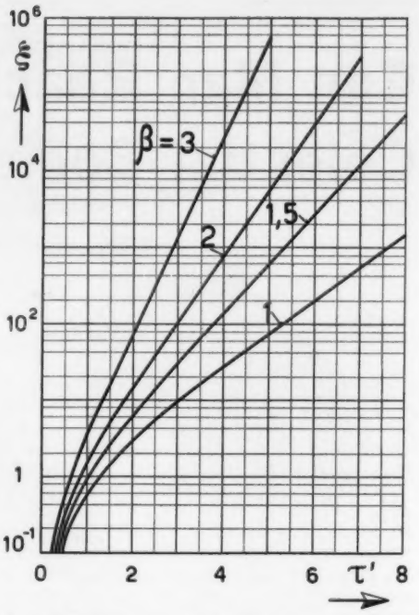


Fig. 2 : Distance covered in light years ξ during one period of acceleration. Vehicle time τ' (for an observer in the vehicle) is given in years ; the parameter is acceleration βg.

Let us assume, for example, that τ' is exactly two years, in other words that the space traveller's whole trip (without staying at his destination) would take eight years. Let us also assume that acceleration factor β is equal to one, so that space travellers perceive no difference compared with weight conditions on earth. In this case they would not be in a state of weightlessness—an advantage, since it is not yet known whether man can tolerate this state for long without damage.

According to *fig. 2* and *equation 15*, ξ is equal to 2.76 light years, the distance of the destination from the earth thus 5.52 light years or 5.21×10^{18} cm, which corresponds roughly to the distance to *Proxima Centauri*, the very nearest fixed star 4.3 light years away. *Equation 12* gives the ratio of maximum vehicle speed to the speed of light as $v/c = \tanh 2 = 0.964$, and *equation 13* factor θ as 1.81.

Fig. 3 : Space vehicle speeds $\varphi = 1 - v/c$ plotted against " vehicle time " τ' for various accelerations βg.

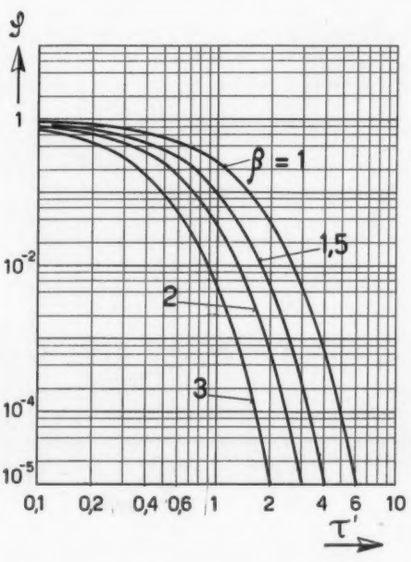
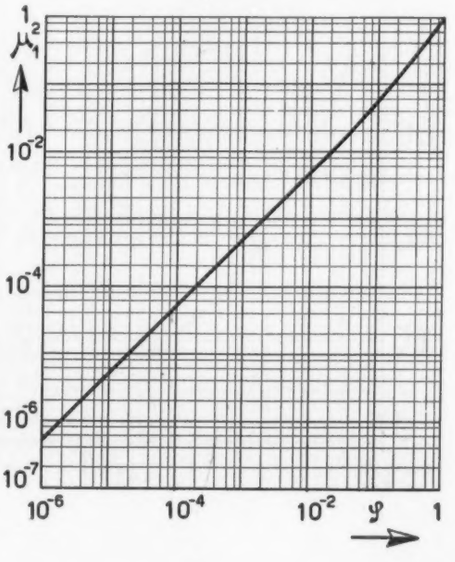


Fig. 4 : Mass ratio required for a photon rocket with full conversion of exhaust mass into radiation energy, for outward journey to destination only.



In other words, in this case the vehicle's maximum speed as measured on earth would have to be 96.4% of the speed of light and the round trip would take $1.81 \times 8 = 14.5$ earth years.

As the space travellers would age by only eight years during the journey, there would be a " time gain " of 6.5 years. On return to earth the travellers would appear 6½ years younger than their contemporaries.

For a journey with higher acceleration or deceleration, e.g., for $\beta = 2$, which would perhaps still be just feasible physiologically (provided the vehicle's occupants remained otherwise motionless), the distance covered and the relativistic " rejuvenation " would be greater: $2\xi = 26.31$ light years; $(v/c)_{max} = 0.9993$; $(\varphi = 0.0007) : \theta = 6.74$. — On earth 53.9 years would have passed, so that the travellers would have gained 45.9 years ... and would thus be biologically " younger " than the children they had left at home.

•

Meanwhile, however, it must be remembered that it requires an enormous consumption of energy in order to approach close to the speed of light. If such extreme speeds are to be attained, *reaction* must be by *light particles* (photons), i.e., a photon rocket (Sänger) must be used. Also it must be remembered that practically the whole propellant mass would have to be transformed into energy and that even so this propellant mass would make up almost the whole mass of the space vehicle. *Today we have just reached the stage, even in nuclear reactions, where roughly one thousandth of the " rest " mass is transformed into energy.*

Admittedly, so long as we are ignorant of the reasons for the stability of protons, it would be premature to maintain that a greater transformation of mass into energy is impossible in principle. If this is assumed as possible, the calculation of mass ratios must be based on the relativistic rocket equation for photons.[3]

The ratio of the mass at the end of the acceleration period to the initial mass can be designated μ_1 and calculated from *equation 18*. For the round trip (with two acceleration and two deceleration periods) $\mu_{tot} = \mu_1^4$ therefore applies *(equation 19)*.

A simple calculation, based for example on the figures for a journey to Proxima Centauri, produces *extreme mass ratios*: a tremendous mass would have to be provided on departure and to be almost entirely radiated, in order to bring a very small mass (crew, cabin, propulsion mechanism) back to earth on completion of the trip. Only if the propellant radiated could be replaced at the destination, or if no return to earth is planned, would the mass ratio become more favourable, as in this case it would be calculated from *equation 20*.

[3] Cf. *J. Ackeret*: Helvetiae physica acta, Vol. 19 (1946), p. 106.

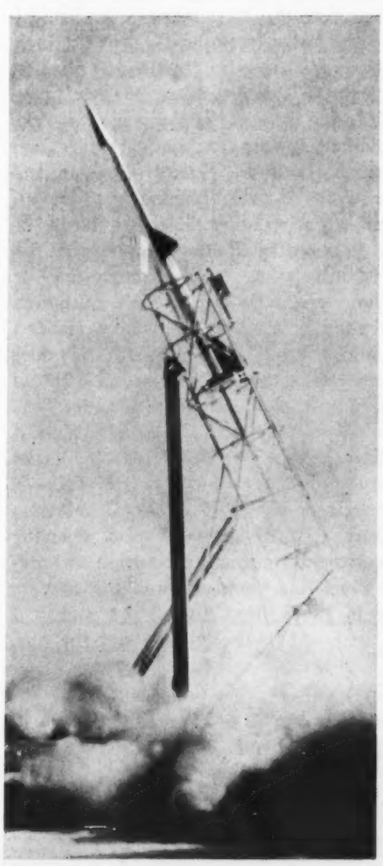
The last equation (*20*) is presented in graph form in *fig. 4*. For example, for $(v/c)_{max} = 0.999$; i.e., for $\varphi = 10^{-3}$, a mass ratio of 1 : 2,000 would be needed. As the ultimate mass of the space vehicle could scarcely be less than 50 tons—since the space travellers would have to be housed, fed, ventilated, lit and heated for at least eight years — the departure mass would have to be at the very least 100,000 tons, and probably considerably more. — *It is thus clear that, even with daring assumptions, there can be no question of space journeys to beyond the nearest fixed stars.*

•

A journey of this kind would have no sense unless it could be hoped to find and explore foreign planetary systems. Here perhaps forms of life very different from our own might be discovered, so that biology might gain.

It must, however, be asked whether there is not infinitely more to be gained from terrestrial research, which after all is only on the threshold of the exploration of life. From the astrophysical point of view the result would probably be small, as 99% of matter is in a gaseous form. An astronomical observation post on the moon will suffice to do everything that can be expected in this domain. Thus the old saying still retains its force:

If thou the infinite wouldst bestride,
Know first the finite on every side.

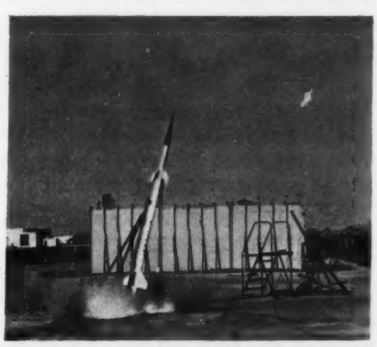


American Two-Stage Rockets

A few weeks ago first details were released of two new types of American research rockets which bear the designations **Hypersonic Test Vehicle** and **Terrapin**. Both are two-stage rockets for solid propellant.

The **Hypersonic Test Vehicle** (left), as the name indicates, is a supersonic vehicle for very high Mach numbers and has been developed over the past three years by Aerophysics Development Corporation (subsidiary of the Curtiss-Wright Corporation) in conjunction with the Wright Air Development Center, Air Research and Development Command. A first test firing was made in November 1954. Meanwhile another 14 rockets have been launched, most of them from mobile launchers at N.A.C.A.'s Wallops Island, Virginia, proving ground. The last rockets in the experimental series reached final-stage speeds equivalent to **Mach 10.5** and climbed " several hundred miles " into the atmosphere.—The first stage has a calibre of 9 inches, a length of 5 ft. and is powered by seven parallel solid-propellant combustion chambers burning simultaneously. After burnout of the first stage the second stage is automatically ignited. It also measures 5 ft. in length, but has a calibre of 6 inches and carries only four combustion chambers. The nose cone of the second stage carries measuring instruments and a magnetic tape recorder. On reaching the maximum altitude, the second stage's four fins are automatically blown off, so that the burnt-out rocket falls to earth in a flat spin at about 100 m.p.h.

The **Terrapin** (right) is a joint development by Republic Aviation Corporation and the University of Maryland (cf. November issue, p. 898), for which Allegheny Ballistics Laboratory and Thiokol Corporation supplied the propellants. The **Terrapin** has also been tested at Wallops Island: length 15 ft., diameter 6¼ ins., launching weight 224 lbs., burnout speed of second stage equivalent to Mach 5.8, peak altitude 80 miles.



Space travel

ELECTRO-GRAVITIC PROPULSION

by LUCIEN A. A. GÉRARDIN, head of the Nuclear Physics Section, Compagnie Française Thomson-Houston, Le Raincy, France

Immense progress has been made in the field of air navigation since Clément Ader first flew his *Eole* over a distance of fifty yards on October 9th, 1890. But the basic principles have not changed.

The propulsive force generated by the power unit in one way or another counterbalances the vehicle's weight due to terrestrial attraction. Though localized to the vehicle's centre of gravity for the sake of simplicity, this force of weight in reality acts on every atom of material. On the other hand, the propulsive force, whose point of application is really localized to the power unit, is transmitted to the whole vehicle because of the latter's rigidity. The balance between these two forces, which in order to be complete would have to be provided at the atom level, is thus obtained only on the average. Because of the vehicle's inertia and its finite solidity, this limits the accelerations possible to a few *g*.

For propulsion to be ideal a balance would have to be created on the atomic level. This is a new approach to the problem which has virtually no point of contact with the present solution.

It would no longer be a matter of generating a force localized at one point, but a field of inertial forces roughly uniform in the whole of the region around the vehicle. With weight thus being balanced on the atom level, there would no longer be any limitation on the accelerations possible.

As this field of forces is no longer strictly localized, the air adjacent to the vehicle will also be carried along. The heat barrier, ultimate limiting factor to the speed of present aircraft, will disappear. Actually, however, the field will decrease as distance from the generator increases. Thus only part of the air will be carried along ; nevertheless the maximum speed obtainable will be very high.

The ability to create such a field of forces presupposes a very wide knowledge of the exact nature of mass and the attraction between two masses. As Professor Bryce S. DeWitt, of Berkeley University, put it in 1953 : " Before anyone can have the audacity to formulate even the most rudimentary plan of attack on the problem of harnessing the force of gravitation, he must understand the nature of his adversary. I take it as almost axiomatic that the phenomenon of gravitation is poorly understood even by the best of minds, and that the last word on it is very far indeed from having been spoken."

Though electrically neutral in the mean, matter is built up of enormous quantities of negative electricity (electrons) and positive electricity (protons). The force of gravitational attraction between two masses of hydrogen of 1 gramme each placed 10 m apart is only 6.7×10^{-14} dynes. The Coulomb force which would exist if these masses consisted solely of protons would be 0.8×10^{14} tonnes, or 1.2×10^{38} times as powerful. An attempt may be made to explain gravitational attraction as due to a very small residue of interaction between electrized particles. Such an attempt at explanation must be guided by the specific characteristics of gravitation.

Gravitational force is always attractive. The only case in which identical electromagnetic quantities are mutually attracted is that of two parallel currents (charges in motion) moving in the same direction. Gravitation may then be connected with kinetic electromagnetic quantities, for example, the multi-polar moments in the nuclei.

In addition, the gravitic field is independent of the medium interposed between the active bodies. It has in fact been verified, during eclipses of the moon, that solar attraction on our satellite is in no way modified by the interposition of the earth. If this field is electro-magnetic, the phenomenon must have a very much higher frequency than anything that has been observed so far. This confirms the hypothesis that the attraction is due to intranuclear movements which could take place at these frequencies.

It is thus clear that knowledge of the nature of gravitational forces is closely connected with the nature of the atomic nucleus. As Frederik J. Belinfante wrote in 1955 : " The discovery of many new types of strange particles during recent years has drawn new attention to the fact that we really don't understand why those particles exist with the properties we observe. Why is a proton 1,836 times heavier than an electron ? Why is there no neutral mu-meson of mass 200 ? Why is hc/e^2 equal to 137 ? An ultimate theory of matter should explain such things. Heisenberg thinks that such an ultimate theory will describe all particles and all of their interactions by the behavior of one single field. Such a field theory would necessarily be non-linear ; otherwise it could not account for the interactions. Describing everything, it must also describe gravity. In order to get used to these two features of the ultimate theory of matter, we do well if we prepare for the future by studying now the non-linear theory of gravitation which we do already possess."

This theory is the unified field theory elaborated by Einstein and Schrödinger. Going back to the fundamentals of the ideas of space and time, Einstein attempted to describe the physical world in a single geometric form. In the unified field theory the basic laws of geometric space are such that the electro-magnetic field and the gravitational field appear as a single superfield. The latter can be split up approximately into an electro-magnetic and a gravitational field only when one of them is markedly preponderant. This theory uses the framework of abstract geometrical spaces and a large number of symbols whose physical interpretation is extremely difficult.

This interpretation is all the more difficult in that, though numerous purely electromagnetic or purely gravitational phenomena are known, there are practically no examples where the two fields are closely mingled, except perhaps Blackett's effect, namely the magnetic field engendered by the masses in rotation (earth, sun, other stars and probably the galaxy).

The latter phenomenon should be the counterpart to the generation of the field of propulsive forces considered above. Such propulsion must thus be described as electro-gravitational. This definition, however, qualifies only the principle of the generator, but gives no help towards its practical realization.

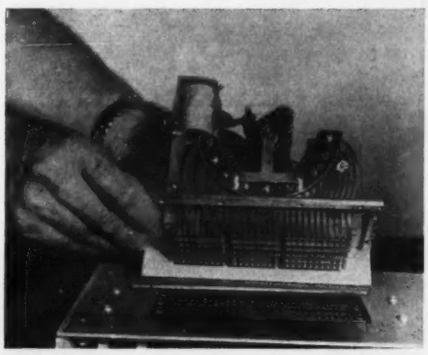
In 1955 *Ansel E. Talbert* wrote in the " New York Herald Tribune " : " Up to now no scientist or engineer—so far as is known in scientific circles—has produced the slightest alteration in the magnitude or direction of gravitational force although many cranks and crackpots have claimed to be able to do this." But this certainly does not mean that the thing is impossible and that our century will not see vehicles with electro-gravitational propulsion. After all, it took only some ten years to reach industrial mastery of atomic energy. *George S. Trimble*, Vice-President of The Glenn L. Martin Company, recalled this fact when, referring to electro-gravitational propulsion (a problem which his company was the first to tackle in the United States), he said : " I think we could do the job in about the time that is actually required to build the first atomic bomb if enough trained scientific brain-power simultaneously began thinking about and working towards a solution. Actually the biggest deterrent to scientific progress is a refusal of some people, including scientists, to believe that things that seem amazing can really happen."

EQUIPMENT ROUND-UP

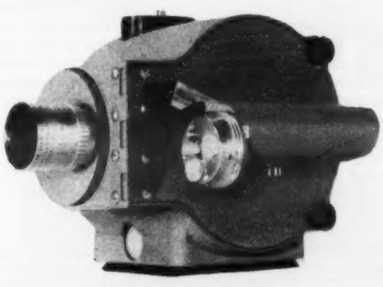
● **U. S. Naval Research Laboratory** scientists have developed the 13-ounce "Minitrack" miniature transmitter for installation in the American earth satellites. With the aid of the 10-milliwatt transmitter the satellites launched during the International Geophysical Year will be tracked right round the globe. It consists of a single-stage crystal-controlled transistorized oscillator for a frequency of 108 Mc/s and uses Philco type SBDT 12 transistors. The battery pack (right) consists of seven Mallory type RM 12 mercury cells (1.5 volts each), which will power the transmitter for two weeks. The aluminium container (left) also serves as heat shield and is gold-plated for this purpose.—The "Minitrack" is at present undergoing searching operating tests under extreme conditions at the Naval Research Laboratory.

● **Sperry Gyroscope Company,** Great Neck, New York, recently began producing the world's smallest radar set for the U.S. Army. The set, which weighs only 85 lbs. complete with power supply, is designed for use by ground units in the battle area to detect enemy movements in smoke, darkness or fog. Considerable weight has been saved compared with the normal Army radar (weighing at least one ton) by, among other things, eliminating the cathode ray tube and substituting audible signals. The drum-shaped radar head can be rotated in any direction by means of a lever—rather like a studio camera. As soon as the radar beam detects an enemy vehicle or a group of armed soldiers, a distinctive sound is heard in the observer's headphones; this, together with optical direction indicators, enables bearing and height to be determined. Range of the set, which can be dropped by parachute, is 6,000 yards; power is supplied by a light portable generator.—The equipment was developed by Sperry in conjunction with the Signal Corps Engineering Laboratories, Fort Monmouth, New Jersey, and the Army Electronics Proving Ground, Fort Huachuca, Arizona, and has already been tested in the field.

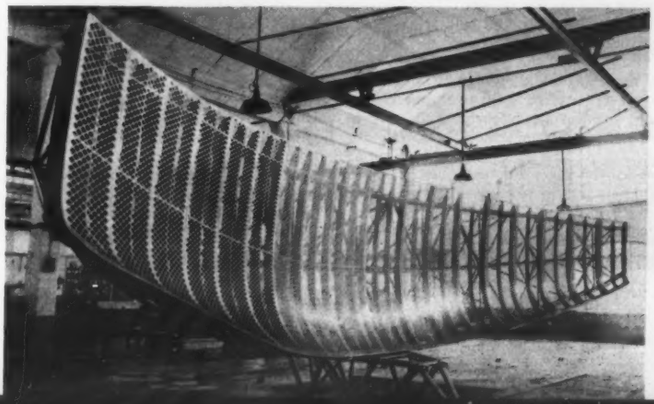
● **Traid Corporation,** Sherman Oaks, California, makers of special cameras of all kinds, has developed—to a military specification—the type 500 high-speed 16-mm camera for speeds of up to 200 frames per second. Operation is guaranteed at up to 25 g loads in any direction, weight is only 10 lbs. The camera can be powered by either a 28V DC or a 115V AC motor and reaches full speed after 1/3 second. The full 200 ft. of film length runs 40 seconds at 200 frames a second; exposure time per frame 1/1000 sec. Price of the camera in a version for two speeds (100 and 200 frames per second) is $ 2.195.



● **Northrop Aircraft Inc.,** Hawthorne, California, has developed plug-in circuit boards with substantially reduced wiring for use in the test equipment for the Northrop SM-62 "Snark" intercontinental missile programme. The device shown here is a 26-position stepping switch, with six contact boards printed on both sides (12 circuits), which are plugged into corresponding sockets. The wiper contact area is rhodium plated, and the actual contact areas gold-plated. The switch is normally sealed in an aluminium capsule pressurized with inert nitrogen gas.—A production licence has been granted to Electrodynamic Division of the United Geophysical Corporation, Pasadena, California.



● **Resistoflex Corporation,** Roseland, N.J.: Fluoroflex-T hoses based on a Teflon compound are being used to an increasing extent in aircraft construction. They are fire-proof, light in weight, versatile and resistant to fuels, synthetic oils, acids, etc. within a temperature range of —70° to +230°C. Through development of a special production process, the company has been able to make thin-walled Teflon hoses for pressures up to 1,000 p.s.i. The Fluoroflex-T Teflon compound used is entirely free of solid flux and impermeable to fuels even under the highest pressure. The protecting braid is of stainless steel. The particular advantage of Fluoroflex-T hosing in the construction of high-pressure hoses is that—unlike conventional rubber hose tubes—it is not subject to critical deformations when pressed into the interstices in the braid (e.g., Fluoroflex-T-R5800 and Fluoroflex-T-R700).



● **Piaggio & C.,** Genoa, has built, under contract to **Microlambda S.p.A.,** the radar aerial reflector 50 ft. wide and approx. 10 ft. high shown here. The tubular structure aerial was designed to a Microlambda specification and can be dismantled into nine components for ease of transport. A small-scale model of the reflector has been submitted to thorough aerodynamic testing in Piaggio's wind tunnel at Finale Ligure, with the object of ascertaining wind forces at different wind speeds and aerial rotation speeds. The results of these tests were taken into consideration in deciding on the dimensions of the reflector and designing its drive mechanism.—All electrical and electronic components were designed by Microlambda, while the rotation mechanism was supplied by another Italian company.

The Mind of Mr. Reader...

I.A.T.A.'s Facilitation Effort

Sir,

You will be interested to know that an editorial " Too Little Customer Service..." in the October 1955 issue of *Interavia Review of World Aviation* received the serious attention of representatives at the recent meeting in Copenhagen of the IATA Reservations Working Group.

Your editorial stressed the need for around-the-clock airline booking facilities in the major European cities and cited a case of particular inconvenience to a passenger in urgent need of reservations information at an hour when no downtown ticket office was open.

As a result, the Reservations Group unanimously recommended that member airlines should request their representatives to look into this situation on the basis of local needs. A more specific telephone listing indicating the carrier's airport office telephone number, and direct night lines to the downtown booking office which remains open the longest, were cited as possible means of minimizing the problem.

International Air Transport Association,
Montreal, Canada

S. RALPH COHEN
Public Relations Officer

Editors often have the impression that they are talking against brick walls, and it is therefore gratifying that an august body such as I.A.T.A. heeds an editorial suggestion —even though one may be justified in saying that "the mills of I.A.T.A. grind slowly but they grind exceeding fine." — Ed. —

Nothing New under the Sun

Sir,

The article by Dr. Ing. E. Kramar in your October 1956 issue (of *Interavia:* " Recent Trends in Aviation Electronics ") states that a 50 kc/s separation between channels on the V.H.F. band seems to be the limit for civil use.

In the same issue our company is advertising V.H.F. equipment for 25 kc/s separation at frequencies in the civil aviation band as well as above and below it. Equipment of this type is in constant use by Pan American and B.O.A.C. and many other users in London and elsewhere. Since it makes many more channels available, it is proving invaluable wherever frequency shortage exists.

The " Ranger " equipment is designed for land and marine mobile use but it passes electrical specifications much more stringent than those required of airborne equipment, and there is no reason why similar equipment should not be used to multiply the number of channels in the civil aeronautic band.

Pye Telecommunications Ltd.
Cambridge, England

J. R. BRINKLEY
Managing Director

Saint-Exupéry—Inventor

Sir,

The discussion as to who was the first in the field of jet lift augmentation (jet flap) has from time to time revealed a regrettable confusion between devices based on control of the boundary layer and the jet flap proper: the ejection downwards of a sheet of gases does much more than control the lift of a wing; it modifies the entire aerodynamic field about the wing.

During my own work in this domain* I discovered, to my pleasant surprise, not merely a forerunner but an *inventor* of the jet flap, in the person of Antoine de Saint-Exupéry, a copy of whose patent No. 850.093 of August 17th, 1938, is enclosed.

Figure 2 of this patent shows what is in effect a jet flap, with the sole exception that the source of the gases is a rocket placed at the trailing edge, with its exit pipe pointing downwards. Extracts from the patent are quoted below:

" Expansion in the downward direction directly causes a lift reaction. Expansion forwards produces an opposite braking effect, if the air in motion is regarded in relation to a stationary body, to the flow of this air mass towards the rear. This is the first aspect of a Joukowski circulation about the wing. Expansion rearwards draws along, by viscosity, the air mass from the upper surface of the wing, accelerating the speed of this flow and thus producing the second aspect of a Joukowski circulation . . . The rocket must be built in such a way as to act . . . over the biggest possible portion of the span. The object is . . . to react on the greatest possible volume of air."

I hope that these brief extracts will convince your readers, or that they will at any rate encourage them to acquaint themselves with this side of Saint-Exupéry's work.

Bertin & C^ie^
Aérothermodynamique et Mécanique Appliquée
Paris

M. KADOSCH

RÉPUBLIQUE FRANÇAISE.

MINISTÈRE DU COMMERCE ET DE L'INDUSTRIE.

DIRECTION DE LA PROPRIÉTÉ INDUSTRIELLE.

BREVET D'INVENTION.

Gr. 6. — Cl. 4. N° 850.093

Fig. 1

Fig. 2

Prix du fascicule : 10 francs.

Pilot, poet, philosopher, author, warrior—now inventor. Saint-Exupéry's genius was as varied as his life, and as time goes by the world becomes increasingly aware of the loss it sustained when Saint-Exupéry failed to return from his reconnaissance mission over France on July 31st, 1944. — Ed. —

Why Undershoot?

Sir,

Some years ago I asked, through the Press, why commercial aircraft consistently follow the procedure of undershot landing technique. I have had no reasoned response, either in the Press or out of my wide acquaintanceship of pilots: and as a passenger I continue to be frightened being landed.

It would be interesting if you were to compile two statistical figures, namely, the number of deaths during the last five years attributable to undershoot accidents, and the number due to all other air accidents put together.

Every runway I know—and I know a large number—bears direct incontrovertible evidence, in the form of rubber-marks, of the fact that aircraft commonly touch down between 0 and 20% of the available runway length. To the sophisticated passenger this is the most alarming aspect of flying and is associated with the statistically dominant risk.

I would like to see it established that any touchdown within 20% from threshold of runway length should be a matter for which the captain should have to give an explanation.

Surely it is plain common sense (a) to allow for "+ or − error " rather than just a "+ error ", (b) to tolerate the risk of an overshoot accident groundborne and at low speed, rather than the risk of an undershoot airborne and at high speed.

If I wished to be macabre, I could write a list of at least a dozen relatively recent high mortality accidents due to hitting the ground, or obstructions, which would not have happened if the touchdown target aimed at with a reasonable sense of "+ or −" had been, say, 25% " up ". My guess is that at least 500 lives have been lost in the last five years because of the abandonment of the precept which was respected from the days of Gosport until recenty—" overshoot rather than undershoot ". That precept was laid down before brakes, flaps, reversible pitch-propellers, or undercarriages wide and strong enough to allow swinging at anything over 5 or 10 knots. All these innovations strengthen its practicability.

Piccadilly,
London W.1

Patrick JOHNSON,
A.F.C., C.P.A., A.F.R.Ae.S.

Airlines are in fact worried about the undershoot problem, since many post-war crashes have been on the undershoot. The practice seems to be due to a psychological attitude of the pilots: (a) pride in demonstrating their ability to perform precision landings; (b) a latent fear of brake or reversing propeller failure which would mean that even today's longest runways would suddenly be too short.

— Ed. —

More about " Flight Without Stress, etc... "

Sir,

I would like you to get my new change of address. I have enjoyed your magazine and it will probably be running out soon. How about some articles on the magnetic propulsion field, the solar engines, tapping energy from atmosphere, stars, planets, for travel as the world now possesses many designs. The article by Intel (cf. " Towards Flight Without Stress and Strain . . . or Weight ", *Interavia* May 1956 —ED.—) went home pretty deep . . . Engineers and men who know speak of 15 models using tumbling of the electron field creating energy for this type of travel . . .

This theory is being tried and in about 6 years or better it should become a real McCoy. This will be of course in the primary state, then atomic power. But pure magnetic coverage shouldn't be too far around the country corner.

In Germany there was a drawing showing a flying saucer for 350 people using jets on gimbal mounts, then to convert into normal flight later.

How about a real coverage instead of making fun on this issue, it's really important, more than you think.

I'll be looking forward to your staff conducting this run.

Sharpes, Florida

George H. HUGHES, Jr.

Will Reader Hughes please refer to the article " Electro-Gravitic Propulsion " by L. A. A. Gérardin in this issue. — Ed. —

Clément Ader's Eole

Sir,

The article entitled " They Beat Us By 150 Million Years " by Norman S. Currey in the November 1956 issue of *Interavia* follows a practice which is only too current inasmuch as it omits to mention that the Frenchman Clement Ader was the first to build and fly a powered aeroplane . . . This flight took place at Satory near Versailles in 1897 . . .

It seems necessary to dispel the only too widely circulating legend which attributes the first flight by a powered aeroplane to the Wright Brothers.

Paris XV^me^

Jacques MARCHAL,
Engineer.

Opinion continues to be divided. The preponderant view is that the Wright Brothers made the first " controlled " powered flight at Kitty Hawk on Dezember 17th, 1903. Others hold that Ader made his first flight on October 10th, 1890, in the park of the Chateau d'Armainvilliers, his second on October 15th, 1897, at Satory. — Ed.

Lufthansa Stays in Hamburg

The Leading Article of the October 1956 issue of *Interavia* (page 771) entitled " Preparing For Elections not Only in Washington—But also in Bonn " alluded to reports emanating from Germany alleging that *Lufthansa's* Engineering Base might be moved from Hamburg-Fuhlsbüttel Airport to Frankfurt. The Department of Transport of the Free Hanseatic City of Hamburg has now addressed a formal denial of these reports to the Editors.

* Cf., for example, *M. Kadosch*, " Action d'un jet transversal à un écoulement ". Bulletin de la Société Française des Mécaniciens, No. 18.

Book Reviews

I trasporti aerei nel quadro dello sviluppo dell'economia nazionale nel decennio 1955-1964. — Memorandum for the 6th Italian Transport Congress (Milan, February 25th to 27th, 1956), by Professor Alfredo Crocco (Italian, 80 pages).

An account of past and a forecast of future operating figures, financial results and organizational aspects of Italian air transport by a qualified author, son of General G. A. Crocco and head of the Air Transport Institute at the University of Rome. The latter has avoided the cardinal error so often found in analyses of air transport economy, that of isolating air transport from the economy as a whole, as if it existed in an ivory tower. Professor Crocco paints a clear, unvarnished picture of the organizational and financial problems facing the whole Italian transport system (rail, road, ships, air). He comes to the conclusion that the system must continue to operate at a loss unless the various forms of transport can be coordinated rationally and full advantage taken of technical and economic progress. If this can be done, however, then the author forecasts a bright decade for Italian air transport. The significance of such a coordination in Italy's transport economy goes far beyond the purely national framework. In fact, Professor Crocco's arguments should have a stimulating effect on the Strasbourg Conference's efforts towards coordination of the whole of European air transport.
He.

Recent Developments in Air Law. — By Bin Cheng. Reprint from "Current Legal Problems 1956".— Published under the auspices of the Faculty of Laws, University College, London.—Stevens & Sons Ltd., London, 1956 (English; 25 pages in pamphlet form).

A brief, but instructive analysis of two diametrically opposed legal problems: the question of the upper limits of airspace sovereignty (in view of the coming era of space travel) and a short comment on the revision of the Warsaw Convention as contained in The Hague Protocol of 1955. The only connecting link between the two problems is their topical interest and the notable logic and care with which the author handles his at times complex subject matter. Well worth reading.
He.

Motori per la propulsione aerea. — By Dr. Ing. Ernesto Macioce.—La Tipografica Arpinate, Arpino, 1956 (Italian; 254 pages).

The author, Captain in the Italian Air Force Engineering Corps, here offers a concise treatise on aircraft engines, from the piston engine via the turbojet and turboprop to the pulse-jet and the rocket motor. His book is divided into two parts: Part I (7 chapters) deals with the basic characteristic values for the structure and performance of engines; Part II (4 chapters) is devoted to a number of special questions, in particular those of dimensioning, vibrations and engine aerodynamics. Readers are expected to have some previous technical knowledge.—Many diagrams, lengthy bibliography.
Ri.

Books received

Britain's Aircraft. — A Representative Review of Current Aircraft and Aero-Engines. — Temple Press Limited. (Price 2 shillings).

Der Flugleiter. — Report No. 3, October 1956, of the Verband Deutscher Flugleiter e.V. Edited by Hans Werner Thau, Hanover Airport.

Die Verkehrsentwicklung des Landes Nordrhein-Westfalen — 1. Vierteljahr 1956. — Published by the North Rhine-Westphalia Minister of Transport and Economy. Report No. 28, June 1956.

Publications scientifiques et techniques du Ministère de l'Air. — Distributed by the Service de documentation et d'information technique de l'Aéronautique, Paris :

No. N.T. 61 : *A propos de quelques expériences récentes sur la convection de la chaleur et la transformation de l'énergie*, by Pierre Vernotte.

No. N.T. 62 : *Contribution à l'étude de la combustion des bases pyridiques*, by Jean Ploquin.

No. 316 : *Sur la désorganisation et la restauration à froid de cristaux d'aluminium soumis à des tractions faibles*, by J. Caisso.

No. 317 : *Opérateurs symboliques*, by Henri Pailloux.

No. 318 : *Recherches sur la combustion d'un mélange d'hydrocarbures*, by Jean Rappeneau.

Air is in the Air. — Published by The Hymatic Engineering Company Limited, Redditch, Worcs., England, 1956.

Die Bestimmung der Flugzeugpolaren für Entwurfszwecke, 1. Teil : Unterlagen. — By Dipl.-Ing. D. Fiecke. Report No. 15 published by the Zentrale für Wissenschaftliches Berichtswesen, Deutsche Versuchsanstalt für Luftfahrt e.V., Mühlheim, Ruhr. Westdeutscher Verlag, Cologne and Opladen, 1956 (price DM 52).

Entwicklung und Stand der Luftnavigation. — By Dr.-Ing. E. Rössger. Report No. 25 in the series of technical and economic reports issued by the North Rhine-Westphalia Ministry of Transport and Economy. Printed as manuscript, 1954.

The index to the 1956 volume of INTERAVIA is enclosed in this issue.

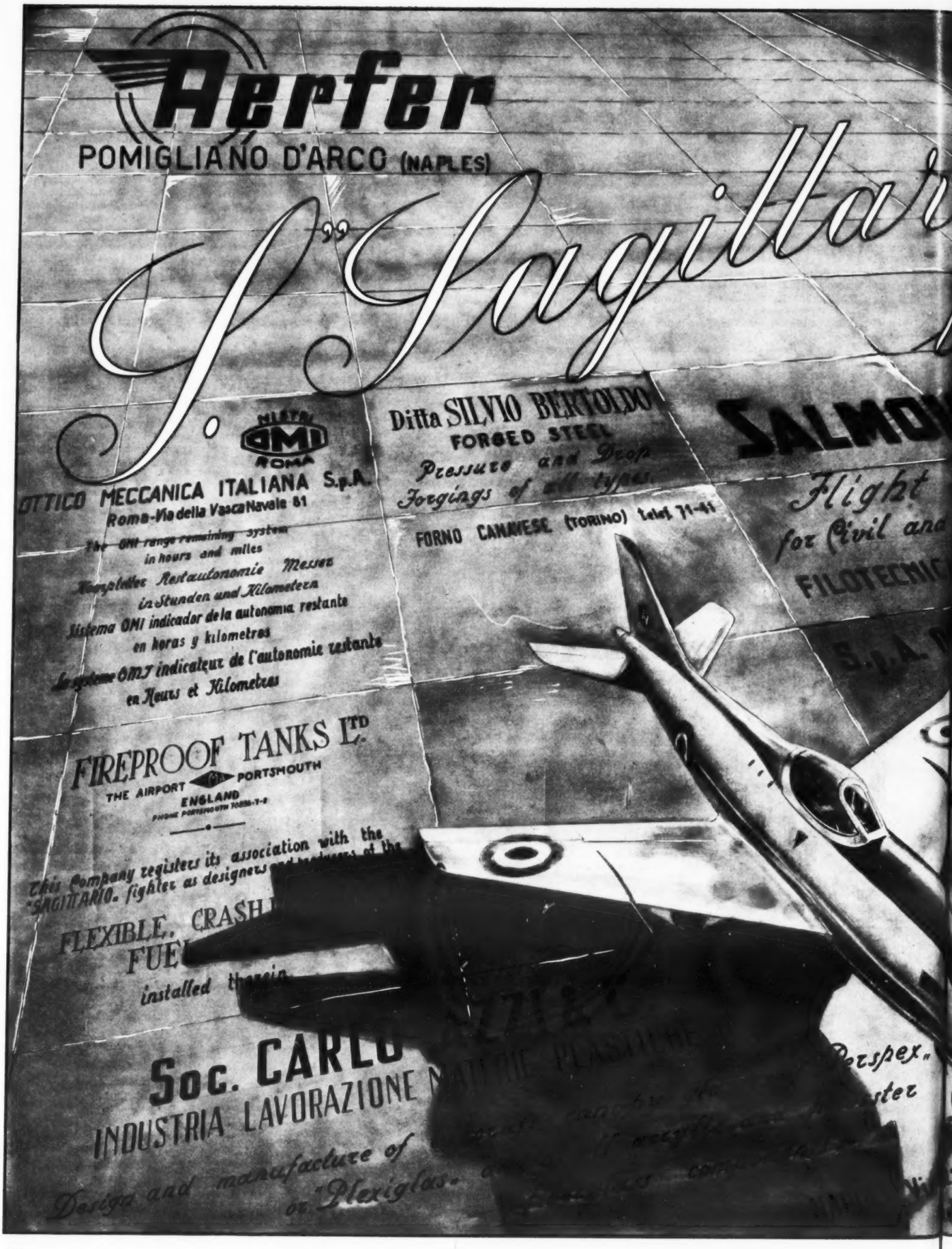
Photo credits : Front cover : Walt Disney Productions ; p. 949 : Publifoto, Rome ; pp. 950-952 : Keystone (1), U.S.A.F. (1), manufacturers (4), Interavia (1) ; pp. 953-955 : Joe Boog, Zurich (1), Department of Defense (3), Interavia files (2) ; pp. 956-959 : Dr. H. Wexler (1), U.S. Navy (1), Interavia drawings (2), Interavia files (1) ; pp. 960-962 : author ; p. 967 : Department of Defense ; pp. 968-969 : manufacturers (6), Interavia files (1) ; pp. 970-972 : author (8), manufacturers (1), Interavia drawing (1) ; p. 973 : Italian Air Force ; pp. 974-977 : author (7), Interavia files (1) ; pp. 978-979 : manufacturers ; pp. 980-982 : Foto Lucca Chmel, Vienna (1), R.N.A.F. (2), U.S. Navy (3), U.S.A.F. (1), U.S. Army (1), manufacturers (4), Interavia files (5) ; pp. 989-991 : author ; p. 993 : U.S. Navy (1), U.S. Army (1), manufacturers (4).

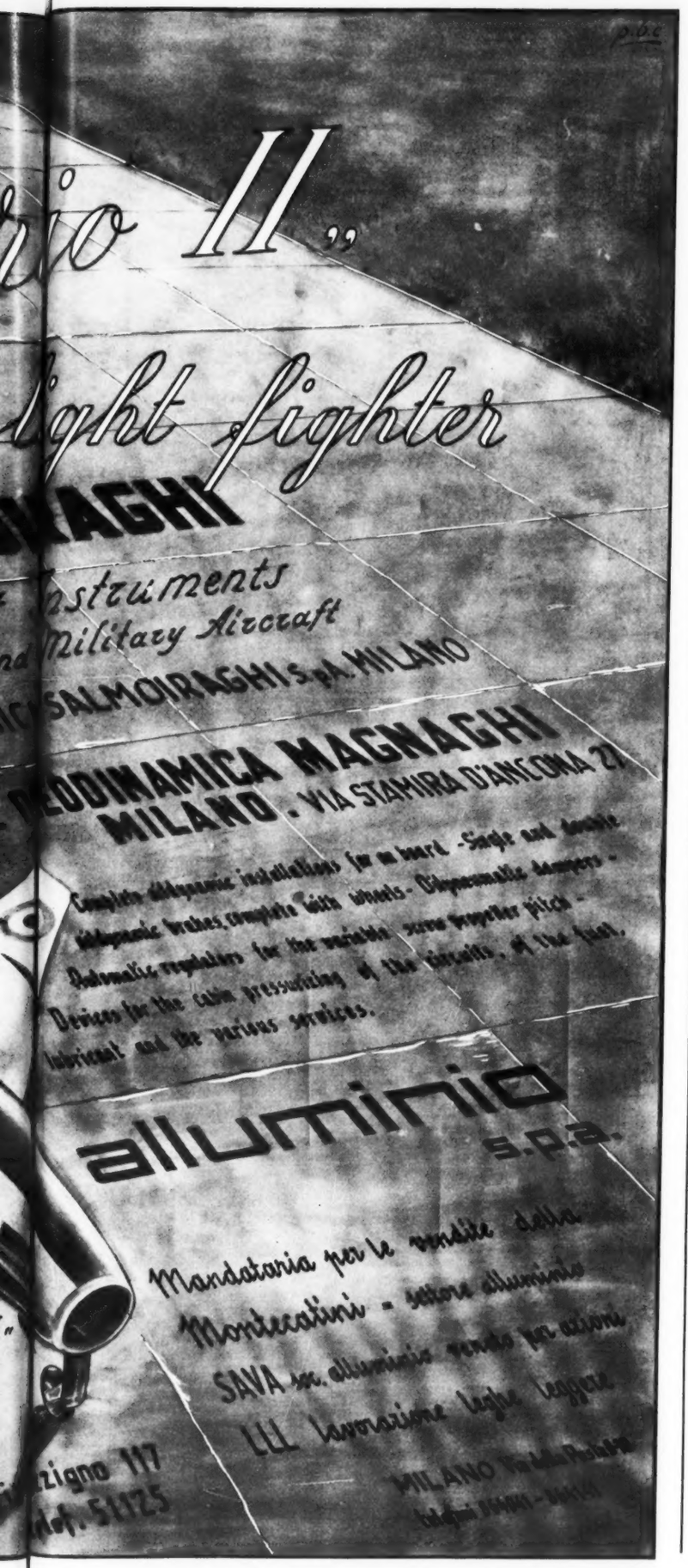
STRÜVER Aircraft Energisers

on European Airfields

Capacities: 35/42 kW, 1500 Amps. 28 Volts with air-cooled DEUTZ Diesel engine 60/66 HP

AD. STRÜVER GMBH AGGREGATEBAU MIT DEUTZMOTOREN **HAMBURG**


Aerfer
POMIGLIANO D'ARCO (NAPLES)
"Sagittario"
OMI
ROMA
OTTICO MECCANICA ITALIANA S.p.A.
Roma-Via della Vasca Navale 81
Ditta SILVIO BERTOLDO
FORGED STEEL
Pressure and Drop
Forgings of all types
FORNO CANAVESE (TORINO) Telef. 71-41
SALMO
Flight
for Civil and
FILOTECNIC
FIREPROOF TANKS LTD
THE AIRPORT PORTSMOUTH
ENGLAND
"SAGITTARIO" fighter as designers
FLEXIBLE, CRASH
FUE
installed therein
Soc. CARLO
INDUSTRIA LAVORAZIONE
Design and manufacture of
or "Plexiglas"
Perspex"
ster


Light fighter
SALMOIRAGHI S.p.A. MILANO
AERODINAMICA MAGNAGHI
MILANO - VIA STAMIRA D'ANCONA 27
Complete hydraulic installations for on board - Servo and booster
hydraulic brakes complete with wheels - Oleopneumatic dampers -
Hydraulic regulators for the variable screw propeller pitch -
Devices for the cabin pressurizing of the aircrafts, of the fuel,
lubricant and the various services.
alluminio
s.p.a.
Mandataria per le vendite della
Montecatini - settore alluminio
SAVA soc. alluminio veneto per azioni
LLL Lavorazione leghe leggere

WORKING WITH "Textiglass" SAVES 5 years

★ HIGH MODULUS FABRIC

"Textiglass"

"glassfiber fabric for reinforced plastics" has designed glass fabric to give in all cases :

- maximum resistance in 2 directions.
- maximum modulus of elasticity.
- optimum homogeneity
- highest electrical qualities.
- highest resistance to shock.

H.M. fabrics (French and foreign patents) are the only ones to meet these high requirements - Numerous test certificates from France and abroad.

"Textiglass" assists its clients up to the stage of industrial production.

"Textiglass" does not compete with its clients

"Textiglass"

★ DOCUMENTS AND SAMPLES ON REQUEST

IN FRANCE :

Pierre GENIN & Cie, S. A.

SALES : LYONS
44, Rue Paul-Valéry - PARIS (16e)
Tel. : PASsy 13-91 (3 lines)

TEXTIGLASS INTERNATIONAL

UNITED STATES :
J. P. STEVENS - New York

GREAT BRITAIN :
FOTHERGILL & HARVEY, Manchester

SCANDINAVIA :
A. B. SVENSKA - Sidenvaveriet, Helsingborg

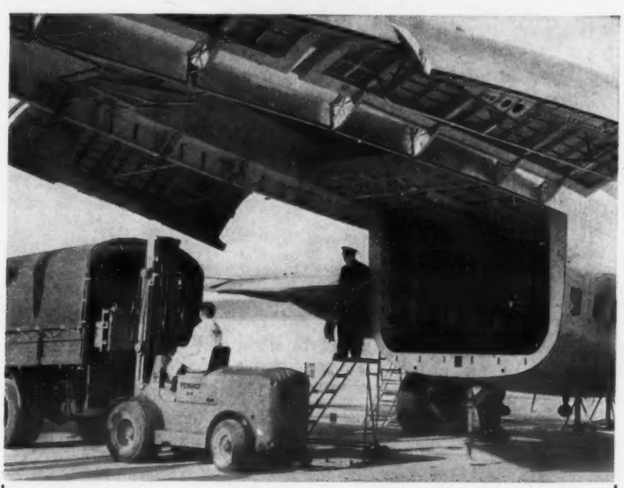
JAYBERT

20, Via L. Bissolati - ROME

L.A.I.'s network of more than 25,000 miles connects Rome and other major Italian cities with the world

FLY LAI

LINEE AEREE ITALIANE



A FENWICK lift truck, with hydraulic clamping device, unloading a BREGUET Deux-Ponts.

for rapid transport

. . . rapid handling

with a

FENWICK

YALE LICENCE

15, Rue Fénelon - PARIS 10e - Tel.: LAM. 91-60

COSTRUZIONI AERONAUTICHE

GIOVANNI AGUSTA

PLANT AND AIRFIELD AT

CASCINA COSTA - GALLARATE

AGUSTA AZ. 8 AIRCRAFT

AGUSTA-BELL HELICOPTERS

JET ENGINES
LANDING GEARS

Hispano Suiza

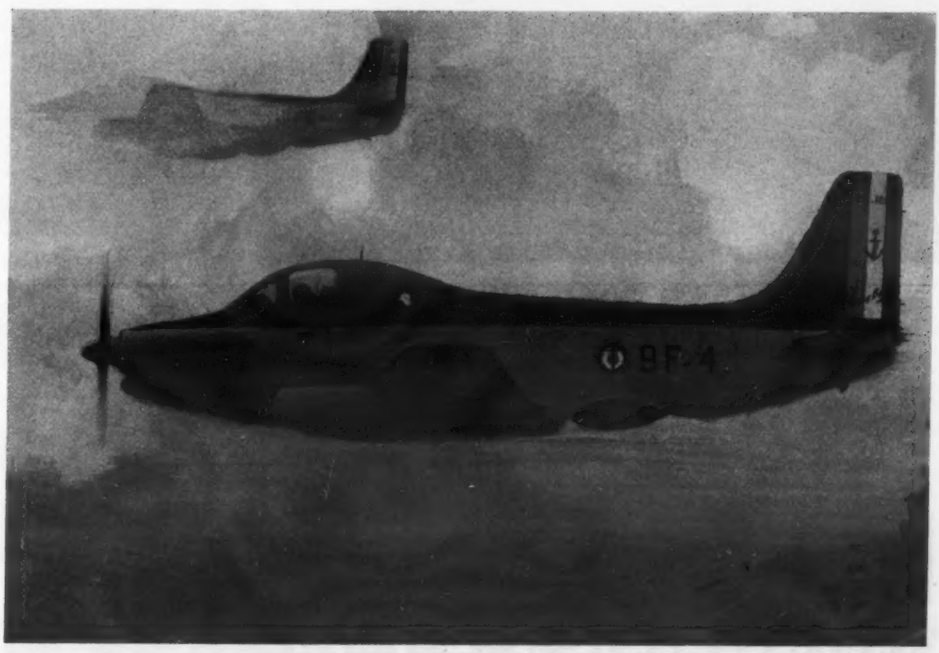
BOIS-COLOMBES_SEINE

AVIONS Louis Breguet

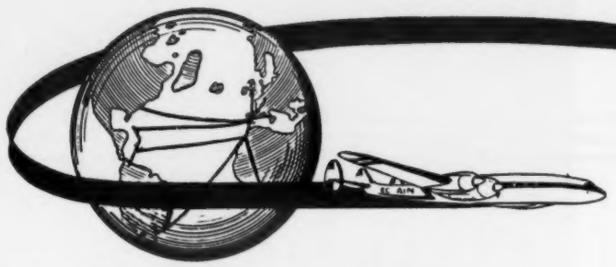
BREGUET 1050

THREE-SEAT
CARRIER-BASED
ANTI-SUBMARINE
AIRCRAFT

FITTED WITH ONE
ROLLS-ROYCE
DART
TURBOPROP

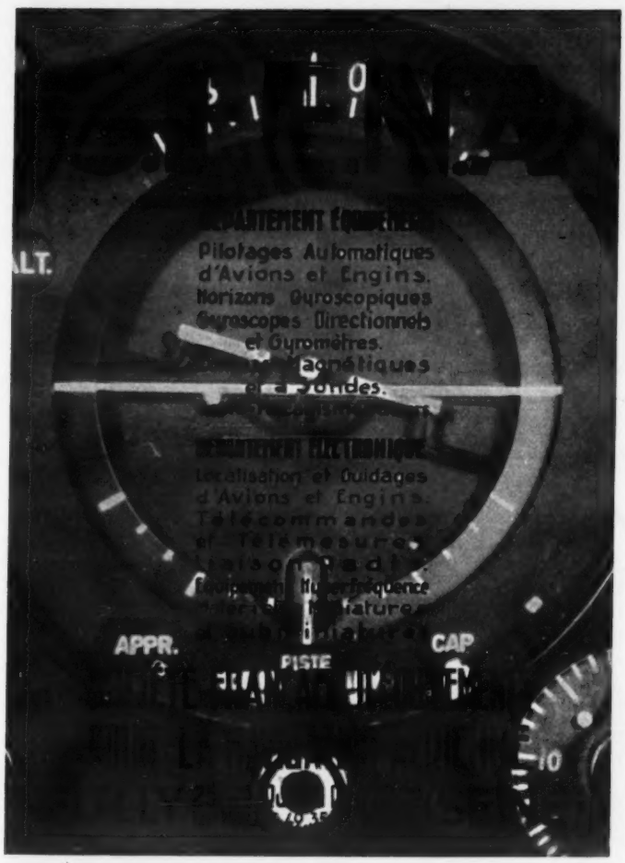


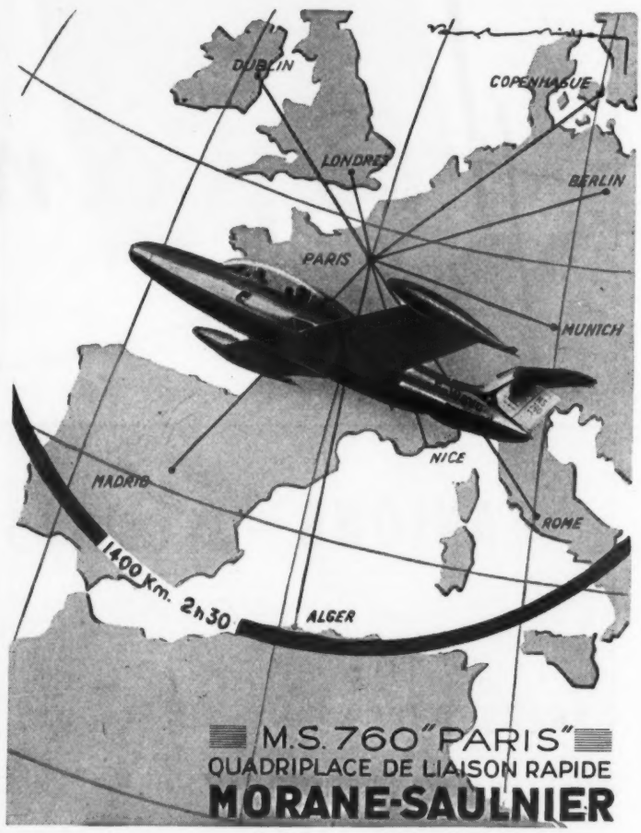
S. A. DES ATELIERS D'AVIATION LOUIS BREGUET - 24 RUE GEORGES BIZET - PARIS



SERVICES LINKING
4 CONTINENTS

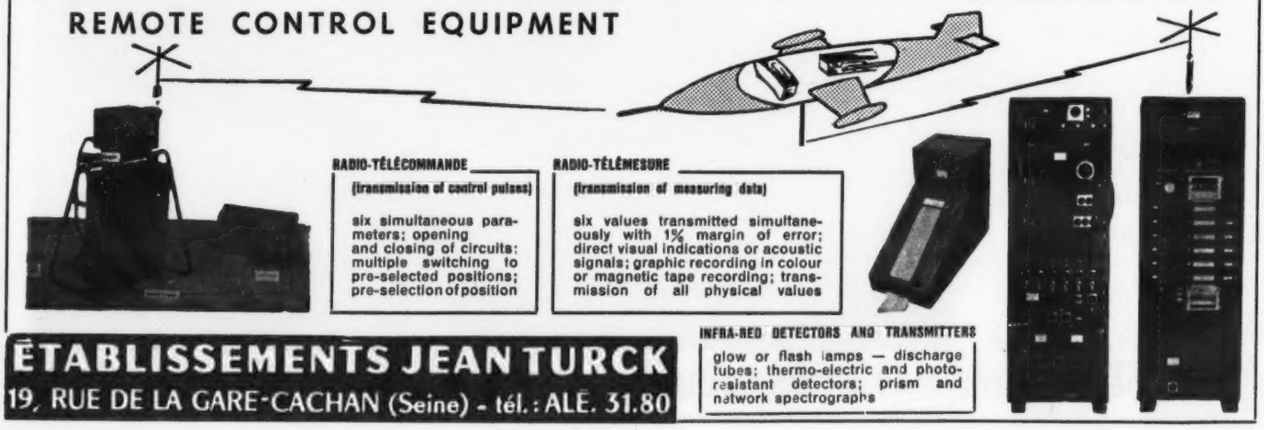
Iberia
LINEAS AEREAS ESPAÑOLAS





M.S. 760 "PARIS"
QUADRIPLACE DE LIAISON RAPIDE
MORANE-SAULNIER

REMOTE CONTROL EQUIPMENT



RADIO-TÉLÉCOMMANDE
(transmission of control pulses)

six simultaneous parameters; opening and closing of circuits; multiple switching to pre-selected positions; pre-selection of position

RADIO-TÉLÉMESURE
(transmission of measuring data)

six values transmitted simultaneously with 1% margin of error; direct visual indications or acoustic signals; graphic recording in colour or magnetic tape recording; transmission of all physical values

INFRA-RED DETECTORS AND TRANSMITTERS

glow or flash lamps — discharge tubes; thermo-electric and photo-resistant detectors; prism and network spectrographs

ÉTABLISSEMENTS JEAN TURCK
19, RUE DE LA GARE-CACHAN (Seine) - tél.: ALÉ. 31.80

RADIO-SWITZERLAND

Limited Company for Wireless Telegraphy and Telephony

MANAGEMENT :

Hauptpostgebäude, Berne. Tel. 2 26 03

SEND YOUR TELEGRAMS

VIA RADIOSUISSE

Direct wireless connections with all parts of the world

Telegrams « Via Radiosuisse » may be handed in at any Swiss telegraph office

Charges are the same as for wire telegrams

AU 128

ZENITH STROMBERG

MAKES ALL EQUIPMENT FOR FUEL
FILLING
CIRCULATION
FEED
FOR ALL AIRCRAFT

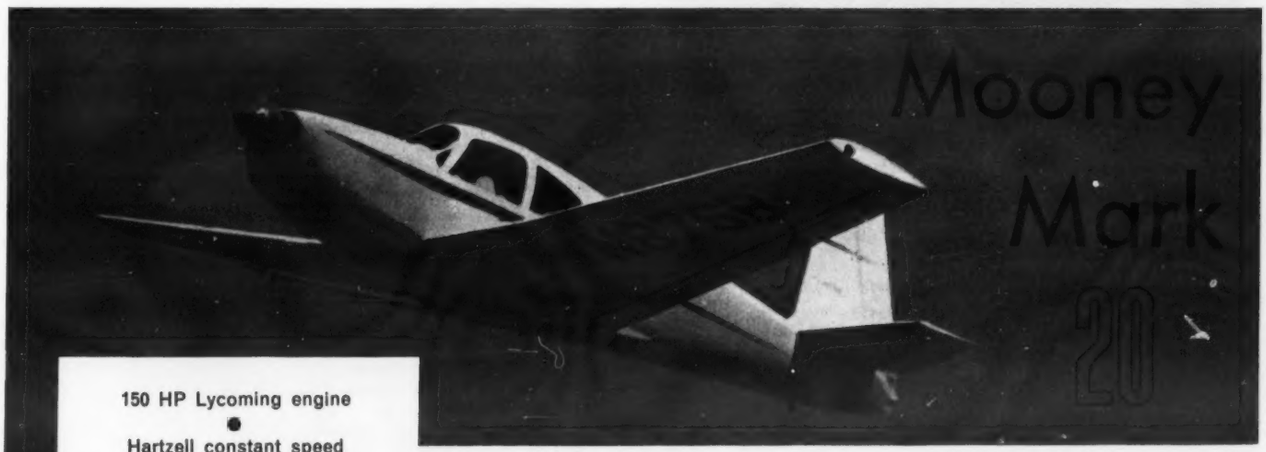
☆

LICENCES FROM HOBSON-FLIGHT REFUELLING
PLESSEY-SAUNDERS VALVE

☆

EQUIPS THE PRODUCTION
MARCEL DASSAULT "MYSTÈRE"
FOUGA "MAGISTER"
S.N.C.A.N. "NORATLAS"
S.N.C.A.S.O. "VAUTOUR"

26 à 32, rue de Villiers - LEVALLOIS-PERRET



150 HP Lycoming engine
●
Hartzell constant speed variable pitch propeller
●
retractable tricycle undercarriage with steerable nose wheel
●
laminar profile wing
●
dual controls
●
RAPID DELIVERY

THE MOST ECONOMICAL FOUR-SEATER

CRUISING SPEED :	165 m.p.h.
STALLING SPEED :	57 m.p.h.
PAYLOAD :	1 030 lbs.
RANGE :	900 miles
CEILING :	20,000 ft.

SOLE AGENTS FOR EUROPE AND NORTH AFRICA :

ÉTABLISSEMENTS TRANCHANT

4, AVENUE DE L'OPÉRA
PARIS 1er OPÉRA 80-93

1001

Snap-on Covers
for the 1956 volume of
INTERAVIA

will be ready from mid-January 1957 onwards

Price:

Switzerland Sfr. 10.—
Abroad Sfr. 11.—

post free

but exclusive
Customs charges

For Sale or Charter

North American T6-F Military or Civil Trainer

AIRCRAFT

with or without Airworthiness Certificates.
Large quantities spares available.

OVERSEAS AVIATION LTD.

10, Zimmerweg, Frankfurt/Main, Germany.
Tel. 72 23 12 - Telex 041 1721

List of Advertisers in Interavia December Issue

	Page
Aerfer, Pomigliano d'Arco	996, 997
Aerojet General Corp., Azusa	936
Aircraft Radio Corporation, Boonton	986
Air France, Paris	931
Alitalia, Rome	998
Allison Division of General Motors, Indianapolis	924
Alluminio S.p.A., Milan	997
Avro Aircraft Ltd., Malton	922
Azzi, Carlo, Société, Naples	996
Bendix Aviation Corp., New York	984, 985
Bertoldo, Silvio, Société, Forne Canavese	996
Boeing Airplane Co., Seattle	929
British Petroleum Co. Ltd., London	934
British Timken Ltd., Northampton	938
Bréguet, Louis, Avions, Paris	999
Cointrin Airport, Geneva	940
Contraves Italiana S.p.A., Rome	943
Costruzioni Aeronautiche Giovanni Agusta, Cascina Costa-Gallarate	998
English Electric Co. Ltd., London	946
Fairchild Engine & Airplane Corp., Hagerstown	987
Fairey Aviation Co. Ltd., Hayes	925
Fenwick, Paris	998
Fiat S.p.A., Turin	966
Filotecnica Salmoiraghi S.p.A., Milan	996
Fireproof Tanks Ltd., Portsmouth	996
Goodyear Tire & Rubber Co., Akron	935
Hispano-Suiza, Bois-Colombes	999
Iberia Líneas Aéreas Españolas, Madrid	1000
Kaman Aircraft Ltd., Bloomfield	1004
Kloten Airport, Zurich	932
Lear Inc., Santa Monica	963
Linee Aeree Italiane, Rome	998
Lockheed Aircraft Corp., Burbank	964, 965
Messier, Ets., Paris	983
Microlambda, Rome	942
Morane-Saulnier, Puteaux	1000
Napier & Son Ltd., London	939
New York Air Brake, New York	1003
O.F.E.M.A., Paris	936
Oleodinamica Magnaghi, Milan	996
O.M.I. S.p.A., Rome	996
Omnipol S. A., Prague	933
Ouest Aviation, Paris	928
Overseas Aviation Ltd., Frankfurt	1002
Paris Airport Authority, Paris	930
Radio Switzerland, Berne	1001
Rotol Ltd., Gloucester	988
Sabena, Brussels	923
S.A.G.A.T., Turin	1002
S.F.E.N.A., Neuilly s. Seine	1000
S.N.C.A. du Nord, Châtillon s. Bagneux	937
S.N.E.C.M.A., Paris	945
Strüver, Ad., G.m.b.H., Hamburg	995
Sud-Est Aviation, Paris	941
Svenska Aeroplan A. B., Linköping	944
Textiglass, Paris	997
Tranchant, Ets., Paris	1001
Turck, Jean, Ets., Cachan	1000
United Aircraft Export Corp., East Hartford	926, 927
Zénith, Carburateurs, Levallois-Perret	1001

Roughly 9 miles from the City centre
Runway 7,700 ft. long
Calvert approach lighting
G.C.A. - I.L.S. 3 - P.V.1B
24-channel radio link
24-hour service - Full repair equipment and service
Point of call for national and international airlines
Charter service - tourist service

aeroporto città di torino

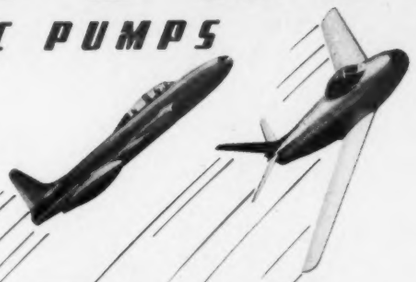
SAGAT
S.p.A. 200.000.000
Head office: Turin
S.Francesco d'Assisi 14
Tel. 526 626
Caselle Torinese Airport
Tel. 982 281 - 982 282
Cable address:
Aertorino-Caselle

Printed in Switzerland

STRATOPOWER®

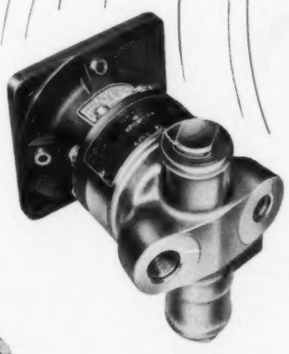
HYDRAULIC PUMPS

On Famous Aircraft of the Free World

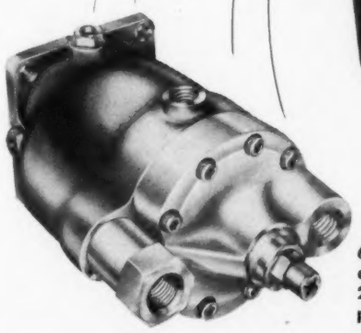


NATO

The Lockheed T33A and North American F86 . . . two jet aircraft of outstanding performance . . . look to dependable STRATOPOWER Pumps for powering Hydraulic Controls. Throughout the world . . . on military, commercial and civilian aircraft . . . STRATOPOWER Pumps provide Fluid Power with maximum economy in size, weight and maintenance. Write for full information on STRATOPOWER Fixed Displacement and Variable Delivery Pumps today.



67V Series STRATOPOWER Variable Delivery Hydraulic Pumps. 1.85 to 3 gpm at 1500 rpm — pressures to 3000 psi.



66W Series STRATOPOWER Variable Delivery Hydraulic Pumps. 2 to 10 gpm at 1500 rpm — pressures to 3000 psi.

INTERNATIONAL SALES OFFICE
THE NEW YORK AIR BRAKE COMPANY
90 WEST STREET • NEW YORK 6, N. Y., U. S. A.
Licensees and Distributors in Principal European Countries

International Sales Office, Dept. F
The New York Air Brake Company
90 West St., New York 6, N. Y., U.S.A.

Please send me information on STRATOPOWER
☐ Fixed Displacement Hydraulic Pumps
☐ Variable Delivery Hydraulic Pumps

Name _____

Company _____

Address _____

City _____ Country _____

KAMAN K-600

The Helicopter You FLY LIKE A PLANE...

Pilots who have never been in a helicopter before are amazed at the ease with which the Kaman K-600 can be flown. Any pilot familiar with fixed wing aircraft can fly the K-600 and fly it well.

The **KAMAN** *Aircraft Corporation*

BLOOMFIELD, CONNECTICUT, U.S.A.

REPRESENTATIVES IN PRINCIPAL CITIES OF THE WORLD